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Online Music Distribution and the Unpredictability of Software Logistics

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2019

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Dissertation submitted to Umeå University in accordance with the requirements of the degree of Doctor of Philosophy at the Faculty of Humanities. November 1, 2019.

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ISBN: 978-91-7855-139-2

Electronic copy available at: umu.diva-portal.org
Printed by Cityprint i Norr AB, Umeå, Sweden

The research of this doctoral dissertation was
funded by the Swedish Research Council
framework grant scheme D0113901.

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Abstract

This compilation dissertation examines the role of software in online music distribution and critically scrutinizes the increased influence of digital technologies in everyday life. In particular, it explores how software coordinates and arranges things, people, and information surrounding music and thereby exerts a logistical power that makes music calculable and governable online. The dissertation consists of four case-studies that problematize the role of software and algorithms in regulating how digital music moves. Article I highlights the role of algorithms in organizing, evaluating, and creating knowledge about artistry, article II uncovers the material, political, and technical networks that facilitate streamed music, article III scrutinizes editorial playlists and their role in packaging and containing digital sound, and article IV traces how software is designed to identify and regulate how music moves and is monetized in the online domain. These case studies draw attention to issues concerning visibility, access, ownership, control, but also—as this dissertation especially aims to highlight—the elements of surprise, unpredictability, and unsettlement that are inherent to complex software technologies.

The research contributes to three subfields in media and communication studies: music-oriented media studies, materialist media studies, and software studies. It contributes to music-oriented media research by accounting for the role of digital technologies in organizing musical practices and thereby illustrates how algorithms and software must be taken seriously as agents that shape cultural practices surrounding music. Relatedly, the research contributes to materialist- and software-oriented media research by continuing the tradition of paying close attention to the technical constitution of media technologies and reflecting on the power and politics of software logistics and its unpredictabilities. Methodologically, the research builds on—and advocates—a mixed-methods approach that combines the use of digital methods, media archeological tactics, and a technology-oriented ethnographic approach. In combining these methods, the dissertation illustrates the benefit of experimental and qualitative methods in the study of digital technologies and highlights the need to approach software as both an object of study *and* a strategic research tool.

Theoretically, the dissertation mainly draws upon materialist and German media theory (e.g., Kittler 1990; 1999; Ernst 2012; 2016), theorizations of logistical operations (e.g., Neilson 2012; Cowen 2014; Durham Peters 2013; Case 2013; Young 2014; 2015), and theories regarding technological accidents, ruptures and unpredictabilities (e.g., Frabetti 2010; Virilio 2007; Parikka and Sampson 2009; Fuller and Goffey 2012). In doing so, the dissertation highlights how the hidden and seemingly ‘grey’ and mundane task of regulating the movement of online music online is, in fact, a deeply cultural and subject to ongoing power struggles. Ultimately, the dissertation illustrates the continued relevance of media research that critically engages with software, adopts digital and experimental methods in the study of digital technologies, acknowledges the logistical power of software, and accounts for the unpredictable events that software technologies sometimes trigger.

Keywords: Music distribution, logistics, software studies, unpredictability, digital methods.

List of articles

Article I

“Close Reading Big Data: The Echo Nest and the Production of (Rotten) Music Metadata,” *First Monday*, Vol. 21, issue 7. 2016.

Article II

“Unpacking Online Streams”, *APRJA*, Vol. 7, issue 1. 2018.

Article III

“The Editorial Playlist as Container Technology: Notes on the Logistical Role of Digital Music Packages,” unpublished draft. Re-submitted to *Journal of Cultural Economy* in June, 2019 after being accepted with revisions in the first round of peer-review. Currently under the second round of peer-review.

Article IV

“In Pursuit of Musical Identifications: YouTube Content ID and the Politics of Audio Fingerprint Technologies,” unpublished draft. Submitted to *The Information Society* in October 2019. Currently under review.

Acknowledgments

Although this dissertation only has my name on it, no one finishes a doctoral degree alone. Accordingly, there is a wide range of people who have played a significant part in helping me develop, sharpen, and wrap up the text that follows. First of all, I want to thank my supervisors Pelle Snickars and Patrick Vonderau, for challenging my thinking, pushing me out of my comfort zone, and guiding me through the academic maze with great generosity over the past few years. You have taught me that the process of doing research is allowed to be intensely fun and creative, and I hope that I have absorbed enough of your scientific rebelliousness to keep me going for many years to come.

I am also grateful to Anna Johansson and Rasmus Fleischer for all the collaborative work within the Streaming Cultural Heritage project. Thanks to you, I have had the fortune of developing my research alongside a team in ways that are rare within the humanities. In particular, thank you Anna for meeting up with me one February afternoon at café Ritorno back in 2014. If you hadn't taken the time to have coffee with a distressed master's student in need of academic guidance, I would not be here today. And thank you Rasmus for creative and original thinking (+ occasionally introducing dancing and art performances to the scholarly repertoire). It has been an honor and pleasure to work with you both.

I also want to thank Jeremy Morris for providing invaluable and generous feedback on this dissertation when it was in its final stages and Simon Lindgren, who did the same thing when I was halfway through this project. Your feedback and comments have helped me polish and improve this dissertation into what it is. I am also deeply indebted to Jonathan Sterne, who took the time to sit down with me one afternoon in Umeå back in 2014, just a couple of weeks after I had started this project. While I doubt that Jonathan remembers much of this brief encounter, discovering his writings early on in my research process has had a monumental impact on my work. I also want to thank Markus Krajewski for being kind and generous enough to invite me to the Department of Art, Media and Philosophy at Basel University, where this dissertation was finalized.

Without my colleagues in media and communication studies, I am also certain that this dissertation would be a lot less interesting and readable. Thank you Jesper Enbom, Erik Edoff, Annika Egan Sjölander, Erik Lindenius, Roman Horbyk, Karin Ljuslinder, and Merja Ellefson for providing invaluable input to my writings over

the past years. In particular, I want to thank Johan Jarlbrink for always paying attention to details, being brutally honest, and providing magnificent reading tips, and Eric Carlsson for tireless pedagogic guidance and being the best and most down to earth office neighbor I could have wished for. I also owe a lot of gratitude, laughs, insights to Fredrik Norén, André Balz, Petter Bengtsson, Linn Eckeskog, Bram Vaassen, Johan Hallqvist, Jenny Jarlsdotter Wikström, Evelina Liliequist, and all other doctoral candidate colleagues who have ensured that this journey has been a lot less lonely and tiresome.

Over the years, my thinking has also been twisted, challenged, and shaped by countless courses, workshops, and conferences. I especially want to thank Annette Markham for the Digital Methods for Studying Algorithms-workshop at Södertörn; Gabriella Coleman and Paula Bialski for the Leuphana Summer School in Digital Cultures in Lüneburg; Geoff Cox, Christian Ulrik Andersen, Winnie Soon, and Søren Pold for the Transmediale PhD Workshop Research Values in Berlin; and Francis Lee and Lotta Björklund Larsen for the Social Studies of Algorithms Summer School in Stockholm. I am also grateful to a number of people who have invited me to come talk about my dissertation and/or the Streaming Cultural Heritage project in the past few years: Thomas Hodgson at King's College, Richard Rogers at University of Amsterdam, Lisa Parks and Jennifer Holt at USCB, Johan Lundin at Chalmers University of Technology, John Sundholm at Stockholm University, Hendrik Storstein Spilker at University of Trondheim, Loïc Riou at Mines ParisTech, and Mikolaj Dymek at Södertörn University.

This dissertation also owes its existence to the Swedish Research Council for their generous financial support of the research project Streaming Cultural Heritage (framework grant scheme D0113901). Likewise, I am indebted to Doug Seary and everyone else at MIT Press, who took on the *Spotify Teardown*-book where excerpts of this dissertation—especially with regards to article II—have been published (Eriksson et al. 2019). I am also thankful for having had the chance to collaborate with the wonderful staff at Humlab, Umeå University. Thank you Stefan Gelfgren for providing a fantastic space for experimental and collaborative thinking and giving me the opportunity to assist in the development of the Tech Breakfast seminar series. And thank you Roger Mähler, Fredrik Palm, and Andreas Marklund for being patient enough to always answer my technical questions and agreeing to assist in the development of the digital methods used in this dissertation.

Outside of academia, I also want to thank my family and friends who are some of the smartest, kindest and most wonderful people I have ever come across. In particular, I want to thank Alexandra (for being so incredibly intelligent and wise), Therese (for hour-long phone calls and being my oldest and most adventurous friend), Tove (for gardening therapy and spiritual guidance), Matilda (for always listening and making me laugh), and Josefin (for always, always calming me down). I also want to thank my closest family: mamma Ulla, pappa Peder, Robert, Hanna, Henning, Kerstin, Eva, Johan, Håkan, Frida, and those who were with us when this project started but aren't anymore: Eivor and Inga-Lill. You have given me unconditional support and encouragement throughout this journey, even though I suspect you have often been wondering what on earth I am actually doing. Thank you for that, and thanks for giving me reasons to take a break to occasionally think about something entirely different than this %*)#* dissertation.

Finally, this has been the longest and most exhausting journey I have ever embarked on and only one person knows how difficult it has been to finish it. Thank you Erik Eggeling for typesetting and making this dissertation look so nice. But most importantly, thank you for your patience, calmness, kisses, curiosity, fabulous laugh, and for always insisting on showing me art and beautiful things. Life is so much more fun when you are around.

Maria Eriksson

Basel, October 2019

1 • Introduction

Music has always been on the move. Before music recordings started being shipped across the globe, music moved with people and musicians as they traveled on roads, walked through cities and villages, and sailed over rivers and oceans. While music was bound to live performances, its movement relied on things such as the size and mobility of musical instruments and the ability for bodies to travel through space. In the third century BC, the Ancient Greeks introduced what is believed to be the first agreed system for musical notations; a technique which meant that melodies and rhythms could be saved and distributed through inscriptions (Taruskin 2011). Notation made music transportable beyond the near vicinity of musicians and turned songs into objects that could be collected, stored, and shared. With time, it also transformed music into a commodity that could be bought and sold across markets. The mobility and commodification of music was further reinforced by 19th century media devices and the introduction of mechanical music machines (such as self-playing instruments) and recording technologies (such as the phonograph), that fixed live music in space and time and made it portable and sellable across geographic distances.

Once music was captured in wax cylinders and later shellac discs, it started to move on rail tracks, in the back trucks and tucked into the cargo of ships. Soon, it was also sent through the air in radio broadcasts, mass-reproduced in factories, and transported through television cables and communication satellites. Throughout this history and until the present day, the movement of music has been conditioned by material limitations such as the price and availability of raw materials and the

durability and material affordances of recordings. The movement of music has also been conditioned by cultural and political norms and constraints, such as commercial marketing logics, trade and licensing agreements, and the willingness and approval of those in political power. Music has always been on the move, but never free from material and cultural constraints.

Today, a large portion of the world's music moves across the internet. Beginning with the circulation of MP3 files in the decade leading up to the millennium shift, followed by the (illegal) 'Napster moment' in the early 2000's, and continuing with the development of online music stores, internet radio stations, and streaming services, the internet has become the main arena for the supply and delivery of recorded music. In 2015, a significant global shift occurred when digital revenues surpassed incomes from the sale of physical records for the first time in history (IFPI 2016) and key stakeholders within the music industries¹ now assert that nearly 60 percent of their total revenue derives from online sales and consumption (IFPI 2019). Much like radio transmitters, analog recordings, and stereo equipment were once central to the organization of music distribution, the internet is now the dominant way by which music reaches its audience.

The digitization of music distribution has implied that a new type of material, cultural, and technical gatekeepers have been given a substantial influence over how music moves: algorithms and software technologies. Such gatekeepers have for years been operating in the background of the online music economy, ensuring that music travels smoothly through data centers, fiberoptic cable networks, 4G telephone towers, and the intricate layers of minerals, metals, and plastics that constitute digital devices. They have also helped guarantee that online music is discoverable in search engines, is arranged into convenient music recommendations, and is efficiently and accessibly packaged and compressed. The software systems that perform these tasks form part of what Nigel Thrift has described as the "technological unconscious"; i.e., the digital structures that increasingly track, transport, coordinate, position, and govern subjects and objects in the online

¹ I speak of the 'music industries' rather than the 'music industry' to highlight the complexity of actors that have a stake in musical arrangements. As Jonathan Sterne once put it, "there is no 'music industry,'" only "many industries with many relationships to music" (2014a, 53, see also; Williamson and Cloonan 2007).

domain (Thrift 2004).² Such software systems are frequently not seen or noticed, yet they exert significant power over how music circulates online.

For instance, consider the algorithmic systems that scan, filter, and identify vast amounts of online music and thereby orchestrate practices of listening on a global scale. Companies like Gracenote, for example, assert that over 20 billion daily queries are made to their algorithmic music recognition platform which is used to distinguish and classify millions of music recordings by automatic means (Gracenote 2019). The result of such queries are later fed into music recommendation systems on platforms like Apple Music, which currently reaches a monthly customer base of roughly 50 million paying subscribers worldwide (Kelley 2019). In doing so, Gracenote's musical evaluations also have a direct impact on people's ways of navigating music archives and discovering new music.

Similarly, YouTube's Content ID system automatically analyzes more than 400 hours of user-uploaded YouTube videos *per minute* to detect and regulate how copyright-protected content—including music—is appropriated and monetized on the platform (Google 2018). According to Google, Content ID handles more than 98 percent of all copyright disputes that occur on YouTube and has thus succeeded in automating an overwhelming majority of the platform's copyright disagreements (ibid.). Currently, the decisions made by Content ID affects more than 1.9 billion unique YouTube visitors every month, since the system is actively involved in regulating how user-generated videos are accessed and monetized on the platform (ibid.). If a large portion of the world's music now moves across the internet, it is software solutions—such as Gracenote's music recognition system and YouTube's Content ID—that are increasingly endowed with the power to govern how, when, and where such movements take place. By engaging in knowledge production around music and encouraging specific social and economic musical arrangements, algorithms and software solutions are reshaping what the music industries look like in the 21st century.

² When speaking of the technological unconscious, Thrift extends the ideas of Patricia Ticineto Clough, who introduces the concept in the book *Auto Affection: Unconscious Thought in the Age of Teletechnology* (2000).

The delegation of responsibilities and decision-making processes to digital technologies within the music industries forms part of a broader cultural, political and economic shift that has been ongoing since the invention of computers during World War II. This shift has involved an intensified expansion of—and reliance on—software and algorithmic systems in everyday life. Today, algorithms and software manage global financial trade (Pasquale 2015; Arnoldi 2015), profile citizens to assess potential terrorist and security threats (Amoore 2009), assist in the wide-ranging construction of knowledge on platforms like Wikipedia (Geiger 2014), and arrange love lives and romantic encounters in online dating apps (Roscoe and Chillas 2014). In short, we live in a time when culture, politics, and economics is increasingly shaped by the predictions, recommendations, classifications, evaluations and decisions made by digital technologies.

This dissertation problematizes the increased influence of software and algorithms in everyday life by examining their role in online music distribution. In particular, it explores how software coordinates and arranges things, people, and information surrounding music and thereby exerts a logistical power; i.e., the power to discipline and govern subjects and objects through the measurement, standardization, regulation, and optimization of movement (Neilson 2012; Durham Peters 2013). By paying attention to how power and politics are materialized in software, I critically explore how digital technologies increasingly shape, manage and regulate public as well as domestic life. The aim of this research is to shed light on a set of software technologies that exert a growing amount of power over how music is accessed and encountered and thereby also engage in a wider critique of the power and influence of digital technologies in society at large.

The dissertation builds on two interrelated assumptions. First, I assume that the increased influence of digital technologies in everyday life calls for an in-depth and critical understanding of their workings and power. While much research in media and communication studies have focused on user practices, processes of meaning-making, and the significance of the messages that people express through digital media, I argue that there is a need to get closer to machines to study and critique the power dynamics they entail. Hence, I align with a growing number of materially-oriented media scholars who pay attention to the technical and material dimensions of digital media (e.g., Gillespie, Boczkowski, and Foot 2014; Beer 2013;

Allen-Robertson 2017) and explore how culture, politics, and power is embedded in digital technologies.

Second, my research starts from the assumption that software technologies represent a particularly important dimension of digital media. At a fundamental level, software “consists of lines of code—instructions and algorithms that, when combined and supplied with appropriate input, produce routines and programs capable of complex digital functions” (Kitchin and Dodge 2011, 3). Software regulates the speed and modes by which digital events and processes take place and in so doing “reshapes information exchange, transforms social and economic relations and formations, and creates new horizons for cultural activity” (ibid.). This, I argue, implies that software technologies also need to be taken seriously as objects of study. To ask critical questions about software is, as Matthew Fuller has put it, to explore “some of the fundamental infrastructures of contemporary life: computational structures, entities, and processes that undergird, found and articulate economies [and] entertainment” (Fuller 2017). Hence, this dissertation forms part of—and contributes to—the growing field of software studies (e.g. Mackenzie 2006; Fuller 2008; Berry 2011b; Manovich 2013; Kitchin 2017; Noble 2018), where software is approached as a key material and technical infrastructure that guides ways of acting, being, and thinking in contemporary life.

The dissertation consists of four case studies—article I to IV—that each explore and problematize the role of software and algorithms in regulating how music moves online. Article I (“Close Reading Big Data”) highlights the role of software in organizing how music and artistry is valued, classified, and made sense of and studies the production of algorithmic ‘music intelligence’ that underlies music recommendation engines. Article II (“Unpacking Online Streams”) explores how digital music content is transported across digital networks and uncovers the wide range of material, political, and ecological entanglements that a single ‘click’ on Spotify—currently the world’s largest streaming service for music—may trigger. Article III (“The Editorial Playlist as Container Technology”) scrutinizes the form and function of editorial playlists and their role in packaging, containing, and optimizing the calculability and financial value of recorded music and listeners. Finally, article IV (“In Pursuit of Musical Identifications”) traces how software is designed to silently monitor and identify online music and analyzes the politics of automatic content filtering on YouTube.

Each of my case studies cast light on the role of software in managing distributive practices within the music industries and show how the seemingly ordinary, neutral, and technocratic task of moving digital sound functions as a key site of value extraction and knowledge production. They also draw attention to issues concerning visibility, access, ownership, control, and—as this dissertation especially aims to highlight—the elements of surprise, unpredictability, and unsettlement that are inherent to complex software technologies. While digital technologies are often framed and promoted as the embodiment of logic, reason, objectivity, and order, the dissertation will show how software solutions also carry disturbing, messy, and unpredictable propensities. The latter, I argue, raises questions about accountability and calls for a need to acknowledge the unforeseeable when software is given the power to intervene in the world.

Music as a window to culture and politics

The music industries constitute a particularly relevant entry-point for critical reflections on software for several reasons. First and foremost, music is an epicenter for culture, power, finance, and politics; it is a cultural domain that carries the capacity to touch and affect us on a deeply personal level, at the same time as it operates as a powerful socio-dynamic force that shapes culture and politics writ large. In doing so, music is also far more than entertainment: it has a profound capacity to affect ways of being, acting, and thinking (DeNora 2004). Music shapes cultural assumptions, frames thoughts, and guides attention. It also functions as a tool for making sense of ourselves and others (Born 2011). Music materializes identities and is intimately connected to topics such as class, race, ethnicity, gender, and sexuality (*ibid.*). Due to this central position in everyday life, the sphere of music is also an area where political struggles play out—not only in relation to the content of music (the meaning and significance of lyrics, melodies etc.) but also in relation to the practices that surround it. People's ways of engaging with music are often deeply commercialized, meaning that a number of stakeholders have a vested interest in its arrangement. As Tia DeNora puts it, control over music in social settings provides an “opportunity to structure parameters of action” (DeNora 2004, 20).

This capacity for musical practices to shape ways of being and thinking has long been recognized by philosophers. As Plato aptly described it already some 2400 years ago, “never are the ways of music moved without the greatest political laws being moved” (Plato 1991, 102). In short, there lies power in the organization of music and ways of listening (Attali [1977] 2009). To control practices around music is to control a dynamic sphere of cultural activity that carries the power to make, sustain, and change social worlds (DeNora 2004). In this way, music can be described as an “instrument of social ordering” (ibid., 7); it assists in orchestrating both mundane to extraordinary aspects of everyday life.

During the last decade, music has also spearheaded digital culture and functioned as a testing ground for novel digital technologies (e.g., Hesmondhalgh and Meier 2018; Wikström and DeFillippi 2016). This has particular relevance for my dissertation since it means that the innovative field of online music distribution can be used as a lens through which the wider impact of digitization can be interrogated and explored. Whether it concerns the development of software solutions aimed at generating content recommendations (article I), compressing and shipping digital content across the earth (article II), filtering and identifying online information (article IV), or using computational strategies to extract value from user practices (article III), online music distribution has been a site of extensive social and technical experimentation. For example, the music industries took pioneering steps in developing the social media-focused forms of cultural entrepreneurship that are now commonplace in much of the creative industries (Tschmuck 2016; Baym 2018). It has also played a key role in shaping and negotiating online copyright laws, whose effects on creative expression and market developments stretch far beyond the music industries itself (Gillespie 2007; Johns 2009).

This forms part of a much longer tradition where music has played a vital role in social, political, and economic transformations. As Jacques Attali has shown, the field of music has historically been placed between the new and the old and therefore remained highly symptomatic of social, economic, and political change ([1977] 2009). Practices around music are inherently unstable, Attali suggests, and at the same time suggestive of new and possible social orders. This means that explorations of the technical conditions that guide the music industries can also function as a window into how digital technologies may impact other creative industries—and society at large (Wikström and DeFillippi 2016). In short, the

sphere of music is a cultural domain where new forms of social, political, technical, and economic organization are continuously tested and explored.

What is at stake in the study of online music distribution, then, is not just the possibility to understand a cultural domain that has profound effects on our notion of self and others, but also the possibility to get a glimpse of what characterizes our current technological condition. Thanks to its tight entanglement with technology and business-driven innovations, the sphere of online music distribution offers a unique opportunity critically reflect on our technological situation—and where it might take us in the future. Hence, this is a study that conducts a close examination of the technical mechanisms that precede contemporary ways of accessing music and culture and thus have profound effects on how we find and enjoy it.

As Raphaël Nowak and Andrew Whelan remind us, “music is not a disembodied or autonomous social force. It is always enacted and encompassed within technological processes, which are in turn constituted, contested, appropriated and imposed under and in relation to specific social, political and economic conditions” (2016, 3). To recognize that music is embedded in—and dependent on—materials and technical devices, means that focus can be shifted away from the study of musical works (i.e., the content or meaning of recorded sounds) and towards the technical infrastructure from which value and practices around music emerge.³ The explicit idea of this dissertation is hence to contribute to contemporary music research by showing how software has “consequences for how people get to music, and for how music gets to people” (Jones 2002, 214). Furthermore, my dissertation contributes to media and communication studies by looking beyond digital interfaces and providing an account of the technical backend of contemporary digital media.

³ This approach to the study of music has also been put forward by the ethnomusicologist Christopher Small, who uses the concept of *musicking* to highlight how music is an ongoing process that draws together a wide range of actors and materials. By transforming the word music into a verb, Small highlights how music is something that *happens*, rather than a static thing. For Small, musicking involves “to take part, in any capacity, in a musical performance” (Small 1998). As Jonathan Sterne has later pointed out, this conceptualization of music as process opens up for considering the role of a wide range of objects and technologies in making music happen (Sterne 2014b).

Aims and research questions

The central aim of this dissertation is thus to problematize the increased influence of software and algorithms in everyday life via a close examination of online music distribution. This is done by exploring how four different software technologies are involved in arranging musical practices online. Article I focuses on music recommendation engines, article II studies content transmission protocols, article III reflects on the playlist format, and article IV explores audio fingerprinting algorithms. In each of these studies, the field of music is used as an entryway for asking broader questions about the role of software in mediating and controlling how cultural content moves across the digital domain. One could thus say that I approach online music distribution not primarily as a music scholar, but as someone who uses online music distribution as a lens to explore the wider political and cultural implications of digitization.

My research is guided by an overarching interest in studying the techniques by which software technologies organize the movement of music online. This work is guided by two interlinked research questions: What cultural logics are embedded in software technologies that regulate online music distribution? And how does software manage relationships between people (artists, music fans) and things (data, recorded sounds) in the online domain? These questions are undeniably broad—yet concretized by each of my case studies that zoom in on, interrogate, and explore specific software arrangements. In answering these questions, the ultimate goal is to raise awareness about the function and role of software systems in governing online information flows and thereby open them to scrutiny and critique. As I will argue, the hidden and often unnoticed means by which digital technologies operate online requires research that uncovers, critiques, and disassembles the logics and ideas they sustain. Such research is not least needed so that artists and people in general can make better informed decisions regarding the everyday technologies they use.

While I do not believe that it is possible to get to the full bottom or ‘truth’ regarding the impact and logic of software, my work seeks to probe and experiment with ways of finding gaps and openings that can tell us more about its workings and power. To do so, the dissertation applies a mixed-methods approach that combines the use of digital methods with media archeological tactics and a technologically oriented ethnographic approach. As chapter three will further discuss, my methods are

rooted in digital humanities research, since they involve experimental efforts to re-use digital tools to gather source materials and data. Furthermore, my methods have involved analyzing of a wide range of textual, visual, and audiovisual content concerning software, in order to unpack its logics and operative functions. On a practical scholarly level, this dissertation thus calls for an experimental and interdisciplinary methodological approach in the analysis of software. It also highlights the need to take digital technologies seriously—both as objects of study *and* strategic research tools.

The dissertation is located at the intersection of three academic fields: music-oriented media research, materialist media studies, and software studies.⁴ As stated, I contribute to music-oriented media research by providing an account of the role of technology in arranging musical practices. Here, my dissertation is aligned (and in tune) with a set of music-oriented media scholars who pay attention to the histories, materialities, and politics of digital distributive tools surrounding music (e.g., Morris 2015b; Sterne 2012; Beer 2013). The dissertation contributes to materialist media studies and software studies by continuing the tradition of paying close attention to the technical constitution of media technologies, perceiving these as materializations of politics, power, and culture (e.g. Kittler 1990; Manovich 2013). In particular, I contribute to materialist- and software-oriented media research by providing theoretical reflections on—and empirical accounts of—two topics: the logistical role of software and the unpredictable in software governance.

With regards to logistics, I draw on John Durham Peter’s notion of logistical media (2013), as well as set of broader theoretical conceptualizations of logistical operations (Chua et al. 2018; Neilson 2012; Rossiter 2016; Cowen 2014) to show how a logistical framework is particularly useful for highlighting the *calculative* and *bureaucratic* logics by which software intervenes in musical flows. Simultaneously, I develop a framework for conceptualizing the *unpredictable* events that are triggered when software is endowed with a logistical power and reflect on the errors, surprises, and accidents that tend to arise around software technologies (Virilio 2007; Frabetti 2010). In the following, I will argue that logistical operations must not only be

⁴ Outside the sphere of media studies, it also connects with research in fields such as digital humanities research, science and technology studies, sociology, social anthropology, and political geography.

understood as successful strategies of controlling and making things move, but also a set of practices that cause ruptures, accidents, and unpredictable results. When software is given the ability and power to intervene in the world, it does not always behave in predictable ways. In this dissertation, I therefore reflect on how such unpredictabilities problematize notions of technological progress and functionalist and instrumentalist approaches to technology.

Ultimately, the dissertation shows how the seemingly free-flowing system of digital music distribution is dependent on logistical control where people (artists, music fans) and things (information, recorded sounds), are closely monitored, measured, coordinated, and kept track of. It also illustrates how the logistical influence of software simultaneously triggers unexpected events, which forces us to problematize and rethink the notion that technologies are always under our control. These results have implications for musicians and consumers who distribute and access content online and speak to some of the most pressing current struggles regarding digital technologies, such as debates regarding the extent to which online platforms should be allowed to sell user data and engage in detailed profiling of their customers, and the extent to which the web is forwarding social surveillance and monitoring.

Previous research

My work builds on a large body of scholarly work that has previously studied how software facilitates the movement of music online. While this section will not discuss previous research that relates to each of the technologies studied in my articles (since this can be found in the articles themselves), the discussion that follows will provide a broad sketch of previous research in the field of music-oriented research that focuses on distributive practices online. This research domain is undeniably sprawling, interdisciplinary, and difficult to fence off. What binds most of it together, however, is an interest in the productive, cultural, and political dimensions of circulatory practices. This approach to distributive systems is rooted in recognition of the fact that distribution is not simply about moving things or information from one location to another. Rather, distribution is seen as a set of fundamentally political and cultural practices that regulate “who should have access to content, for what purpose, and on whose terms” (Braun 2015, 6). As Sean Cubitt

describes it, distributive acts and technologies are responsible for organizing “the spatiotemporal orchestration of flows” and involve a wide set of practices and techniques that manage the “acceleration and delay, promotion and restriction” of objects, subjects, and ideas as they move across space and time (Cubitt 2005, 195). As a result, distributive systems also have cultural and political implications; they are sites where economic and political processes are forged and enacted.

One important area of scholarship that has influenced previous research into online music distribution is the social anthropological interest in the “social life” and “cultural biography” of things (Kopytoff 1986; Appadurai 1986). Here, objects are followed and studied as they circulate through cultural domains and thereby acquire different cultural and economic meanings. The key idea, here, is that the environment that surrounds objects fundamentally affects how they are valued and perceived. In other words, the status of objects (as well as people and ideas) change according to their environment, meaning that there are good reasons to study the conditions under which things, people and ideas move. These ideas have for example been developed by Benjamin Lee and Edward LiPuma, whose conceptualization of “cultures of circulation” (2002), has influenced much research regarding online music distribution (e.g., Beer 2013; Durham 2018; Dent 2012). Lee and LiPuma stress that “circulation is a cultural process with its own forms of abstraction, evaluation, and constraint” and therefore call for research that pays attention to the minutiae of distributive practices (2002, 192).⁵ The necessity of paying attention to the practices that surround distribution has also been highlighted by film and television scholars such as Ramon Lobato (2012) and Josh Braun (2015), who note that distributive practices constitute a crucial—but often overlooked—domain in media research. In this dissertation, I align with this growing interest in distributive arrangements around music and perceive circulatory practices as productive sites where power and politics are played out.

In broad strokes, previous research that focuses on the role of digital technologies in online music distribution can be divided into two categories: studies that explore how digital distributive technologies are *adopted* by audiences and/or music

⁵ Lee and LiPuma arrive at this idea by extending the thoughts of anthropological thinkers such as Arjun Appadurai, Charles Taylor, Marcel Mauss, and Bronislaw Malinowski, as well as theorists and philosophers like Jacques Derrida and David Harvey (ibid.).

industry stakeholders, and studies that focus on the *materiality, history, and politics* of digital music technologies in themselves, relating these to broader economic and cultural developments and tendencies.⁶ Research that focuses on how digital distributive technologies are *adopted* by audiences and music industry stakeholders is generally heavily influenced by the aforementioned anthropological conceptualization of circulatory practices and tends to place focus on the social and economic activities and debates that surround online music distribution. Here, processes of meaning and identity-making are often highlighted, as the research explores how digital technologies transform audiences and industry stakeholders' ways of interacting and connecting with the help of digital tools, as well as how they make sense of their online musical activities.

Research that focuses on how digital technologies affect audiences and the consumption of music took off in the late 1990s and early 2000s. Initially, it explored how the internet encouraged new forms of community building among music fans, for example in online forums and discussion groups (e.g., Bryant 1995; Kibby 2000; Ebare 2004; Poblocki 2005). This research aligned with a broader trend in early internet research, where the social dynamics of online or 'virtual' communities were often studied and explored (e.g., Boellstorff 2008; Nardi 2010; Kely 2008). In the decade following the millennium shift, a recurring topic in a substantial amount of research concerning online music consumption centered on online piracy and investigations of how digital technologies allow fans to share and enjoy music in new—but also heavily contested—ways (Burkart 2010; Allen-Robertson 2013; David 2010; Rodman and Vanderdonck 2006). More recently, a focus on consumption practices have been picked up by scholars like Raphael Nowak (2016), who studies how digital distributive tools diversify how individuals listen to and integrate music into their everyday life, as well as Nick Prior (2018)

⁶ Worth mentioning here is also research that focuses on labor that goes into the design and *making* of music technologies. Here, Nick Seaver's ethnographic work, which focuses on those who build and maintain music recommendation systems, stands out (2012; 2017; 2018). Seaver's research aligns with scholars who study how distributive tools are adopted in the sense that it focuses on issues around sociality (in this case, the practices and thoughts of software engineers). Yet it also pays attention to the technical dimensions of software and therefore shares commonalities with materially-oriented research regarding digital music distribution.

and Blake Durham (2018), who both seek to untangle how digital music technologies affect social activities among music listeners.

Relatedly, research that focuses on how music industry stakeholders adopt digital distributive tools has also tended to emphasize that digital technologies allow people to interact in new ways, for example by providing new strategies of promoting music. Two early and essential publications in this regard is Paul Th  berge's *Any Sound You Can Imagine* (1997), which discusses how digital technologies transform processes of making music and create new forms of dependencies between musicians and the tech/software industry, and Mark Katz's *Capturing Sound* ([2004] 2010), which reflects on how digital technologies enable new and collaborative forms of music-making. Scholars like Nancy Baym have also traced the myriad ways through which artists cope—and often struggle—with embracing online music distribution since it brings an inevitable loss of control over how music moves (2010). Baym has also studied how artists develop new ways of connecting with their fans with the help of social media (2012) and engage in new forms of unpaid, precarious, and “relational labor” with regards to their audiences, partly as a result of digital distributive tools (2015; 2018). As a general rule, this branch of research is interested in exploring how digital technologies transform the habits and strategies of performing artists, record labels, and PR agencies etc. It has also shown an interest in studying how such transformed strategies create ripple effects within the music business writ large; for instance by dismantling historical power hierarchies in music retail (T. Anderson 2014), introducing new revenue and compensation models (Spilker 2018), enabling cloud-based and on-demand forms of musical access (Wikstr  m 2009), and encouraging new promotional tactics among industry stakeholders (Meier 2011).

In this dissertation, I complement the above mentioned research regarding the *adoption* of digital distributive tools by aligning with the second branch of research that considers the role of software in online music distribution—i.e., the one which primarily focuses on the *materiality, history, and politics* of digital music technologies. As a result, I put less emphasis on the social activities and discourses that surround digital distributive tools, to the benefit of focusing on how music-oriented software technologies operate and are designed to *do things* the world. The heavy focus on sociality in previous research regarding online music distribution has provided critical insights regarding how digital technologies influence creative and

affective practices around music. Yet there is still much to be said about the technical dimensions of software systems that play an increasingly important role in governing how music moves online. Thus, I locate this dissertation within previous research that emphasize the technical dimensions of distributive music technologies. By ‘distributive’ I do not just refer to technologies that are directly involved in transporting digital music content (as in the case of the TCP/IP protocol discussed in article II), but also technologies that engage in the more subtle management of music distribution, for instance by fueling music recommendation engines (and thereby regulating the promotion—or demotion—of artists, see article I), or engaging in content filtering (that can effectively block online music from circulation or facilitate its ability to move, see article IV).

Early proponents of technology-oriented approaches to digital music technologies were Rebbec Garofalo (1999) and Steve Jones (2002), who called for the need to study how software technologies set music in motion just as the World Wide Web started to gain a real global impact. As in the case of studies regarding online music consumption, early research on the technical specificities of distributive tools concerning music centered on discussions around copyrights and online piracy. Fueled by intensive debates and legal struggles regarding online file sharing in the early 2000s (e.g., Lessig 2004; Lasica 2005; Burkart 2010), this field of research is arguably one of the most widely investigated areas with regards to online music distribution to date. Here, scholars have for example studied the materiality and politics of digital rights management tools, peer to peer technologies, and BitTorrent protocols (e.g. Allen-Robertson 2013; Gillespie 2007; Postigo 2012; Burkart and McCourt 2006), and explored the interplay between legal systems and technical design, showing how online music technologies have been developed in response to changes in copyright law, and vice versa (Burk 2014). This area of research is also comprised of scientific investigations into the development of an “anti-piracy business” (Lobato and Thomas 2012) or “information defense industry” (Johns 2013) that seeks to profit from copyright violations online—often through the development and use of software technologies. In article IV (“In Pursuit of Musical Identifications”) I discuss how YouTube’s Content ID system—as well as other audio fingerprint technologies—can be conceived as belonging to such an anti-piracy industry since they provide an algorithmic and automated form of copyright policing. Apart from that, however, discussions around copyright do not make up a key theme in this dissertation.

More recently, research on the politics and doings of digital distributive tools has tended to move away from discussions regarding online piracy and instead began to focus on the cultural and commercial logics that digital technologies forward and sustain. A significant source of influence in this field has been research into the politics of the online platforms that host, store, serve, and organize access to online content. A ‘platform studies’ approach to digital technologies has been forwarded by Ian Bogost and Nick Montfort who encourage close considerations of the layered and modular technical dynamics of Atari and Nintendo games (2008), Tarleton Gillespie who highlights how online platforms organize access to content and thereby govern communication (2010; 2015; 2017; 2018), and José van Dijk, who scrutinizes the norms, neoliberal values, and forms of “connectivity” that are forwarded by social media platforms (van Dijk 2013).⁷

This form of platform critique has also been picked up by scholars who study how the built architecture of online platforms for music enable and/or constrain agency (Prey 2015), or explore how techniques such as geo-tagging on platforms like Soundcloud and Spotify enable new and geographically based ways of navigating music archives (Audette-Longo 2017). A similar material and political investigative thread can also be found in research that explores how algorithmic music recommendation systems cluster, classify and create meanings around music (Airoldi, Beraldo, and Gandini 2016; Modell 2015; P. A. Anderson 2015; Prey 2019), and thereby function as a type of curators or “infomediaries” that “monitor, mine and mediate the use of digital culture products” (Morris 2015a). My research touches on and discusses two online platforms: Spotify (in article I, IV and III) and YouTube (in article IV), yet I try to break these platforms down into smaller parts, zooming in on specific features that are at work in each of them (editorial playlists on Spotify, the Spotify-owned music recommendation system that is run by The Echo Nest, and Content ID on YouTube). In article I and II I also illustrate the inherent “sprawling, ephemeral networks of interaction that reach beyond any

⁷ Other scholars who adopt a platform-perspective in the study of digital technologies include Ann Helmond who introduces the concept of “platformization” to highlight how platforms have emerged “as the dominant infrastructural and economic model for the social web” and shape of the internet writ large (2015, 1), Taina Bucher who explores how platforms “program sociality” and facilitate interaction on social media sites (2018), Nick Srnicek who studies the underlying capitalist logics of platforms that feed on user data (2017).

platform itself' (Vonderau 2017) by highlighting the operations of web-crawlers and content transmission protocols—an approach that problematizes the notion that platforms are steady and fixated entities and instead illustrates their dynamic and networked dependencies.

To recapitulate, what I share with the above mentioned—and technically oriented—music/media scholars is thus an interest in critically exploring how digital systems (in my case, analytic data engines, playlist packages, content transmission systems, and content filters) are designed, operate, and sustain particular ideas regarding the arrangement of practices around music. Rather than surveying how fans or music industry stakeholders adopt and reason about distributive tools, I have chosen this approach since I am convinced that the technologies that underpin online distributive systems are influential beyond people's ways of reasoning about them. I also believe that a focus on technical dimensions provides a crucial framework for wider reflections on how power in society is transferred to technological systems; a transformation that has bearing for those who are interested in music, but also society at large.

In navigating the terrain of previous (technology-oriented) research concerning online music distribution, three books have been especially important for my work and I would like to briefly mention them here, before moving on to a discussion on theory: David Beer's *Popular Culture and New Media: The Politics of Circulation* (2013), Jeremy Morris *Selling Digital Music—Formatting Culture* (2015b), and Jonathan Sterne's *MP3: The Meaning of a Format* (2012).

While not solely dedicated to music, David Beer's *Popular Culture and New Media* (2013) outlines an approach for investigating the infrastructures that govern the circulation of content online. In particular, Beer pays attention to how vast accumulations of data are generated as a by-product of the activities that take place online; accumulations of data which—after being processed and analyzed—are often fed back into the cultural domain, creating recursive feedback loops that shape culture in return. In doing so, Beer's work provides a clear example of how the distribution of cultural content online is a highly productive domain where culture, economics, politics, and power merge. My dissertation continues his efforts to study how cultural content is “channeled, directed, blocked and stimulated” with the help of digital technologies (ibid., 4) and pays attention to how “the intersections of popular culture and new media have become central in shaping our everyday lives

and in ordering our routine experiences” (ibid., 1). In article I, for example, I resume Beer’s investigations into the vast troves of musical data and information that is generated in the online domain, focusing on how such data is sorted, organized, and made sense of with the help of algorithms and software systems.

In similar ways, Jeremy Morris’s *Selling Digital Music—Formatting Culture* (2015b) focuses on how digital music has been commodified from the 1990s and onwards and provides a useful framework for exploring how music is presented and made valuable in the online domain. Morris traces how digital music (essentially bundles of zeroes and ones) has been packaged, organized, and displayed to become sellable and discoverable in the online domain and thereby shows how the creation of digital music commodities requires ongoing cultural—and computational—work. Morris conducts close studies of several software technologies such as Winamp (an early music player), Napster (an early file-sharing site), and iTunes (one of the first major online music stores); a case-study approach that is picked up in this dissertation. His viewpoints—which highlight the role of software in domesticating unruly music objects and “making digital music behave” (2012)—also re-appear throughout my writings. In article I and article IV, for example, I explore how software controls, regulates, and ‘tames’ music files and the practices that surround them.

Jonathan Sterne’s *MP3: The Meaning of a Format* (2012) has also been a significant touchstone in my work since it provides a vivid display of how industrial conditions and cultural ideas shape the design and function of music technologies. Sterne conducts a detailed analysis of the history and technical function of the MP3 format—one the most common techniques for storing digital audio. In doing so, Sterne highlights the role of seemingly mundane things such as compression and formatting techniques in facilitating the movement of music online. Furthermore, Sterne discusses topics such as ‘perceptual coding’ (i.e., the strategy by which sound technologies, such as MP3s, are designed to mimic human auditory cognition) and ‘format theory’ (a concept Sterne introduces to highlight the role of formats in governing how technologies operate). In article IV, I extend Sterne’s focus on perceptual coding by discussing how audio fingerprint technologies are simultaneously modeled on—and extend—human acts of hearing and thereby make vast amounts of digital sound intelligible and governable. In article II, I also draw upon Sterne’s thoughts on formats to discuss how playlists standardize modes of listening and enable/limit particular ways of interacting with music.

To conclude, then, this dissertation takes its cue from music-oriented media research that focuses on the material and technical histories and operations of distributive software technologies. In other words, this is not a study that primarily seeks to explore the cultural meanings or habits that digital distributive tools give rise to—even if I sometimes briefly discuss how journalists, musicians, and audiences have reacted to the technologies studied. Instead, I seek to engage directly with technology, focusing on how it came into being and is allowed to operate in the world. Here, the medium itself is foregrounded as online content is always molded by the software that brings it into being. As the next chapter will show, this approach is rooted in a much longer theoretical trajectory in media studies that considers the dynamics of the channels through which messages travel.

2. Theoretical framework

This dissertation combines theoretical perspectives from the field of materialist media studies (which highlights the political and techno-material dimensions of media technologies writ large) and software studies (which pays attention to the specific political and techno-material dimensions of algorithms and software). By grounding my work in these two theoretical traditions, I argue that the software technologies studied in this dissertation should be understood as fundamentally cultural and material entities—i.e. as physical carriers of technical, social, economic and environmental relations. Against the background of materialist media theory and software studies, I also argue that algorithms and software must be understood as agents that interfere with the world and create a basis for human action. This means that the role of software in managing online music distribution also needs to be taken seriously as an object of study.

In the following, I present the various theories that have guided me towards this stance with a special focus on theories stemming from the Toronto School (and especially the works of Harold Innis and Marshall McLuhan), as well as German media theory (as developed by Friedrich Kittler, Wolfgang Ernst, and others). The chapter also presents two theoretical and interrelated themes that cut across the articles in my dissertation: the logistical role of software and the unpredictability of software governance. These two themes extend current research in materialist media studies and software studies by providing a framework for conceptualizing the role of software in arranging people/things (i.e. exerting a logistical power) and its tendency to escape instrumentality and give rise to surprise and unsettlement (i.e.

its drift towards the unpredictable). As a whole, then, I combine theoretical insights from the field of materially oriented media studies and software studies—and extend these by discussing logistical media and technological unpredictabilities—to understand and problematize the role of software in digital music distribution.

Materialist media studies

Materialist approaches to media have their origins within the so-called Toronto School of Communication that was developed in Canada in the 1930's–60s and was led by scholars such as Harold Innis and Marshall McLuhan. In short, Innis and McLuhan explored the role of matter and technology in shaping culture and communication. By focusing on the materiality of media—such as the difference between clay and papyrus-based inscription technologies, or photography and audiovisual media—the two highlighted the inherent bias in communication technologies and paid attention to how such biases affect the nature of information and patterns of communication.⁸ As is well known, their key idea was that media technologies are not neutral conveyors of messages but carriers of physical constraints and possibilities that fundamentally affect social interaction and historical development. More than anything, this approach has come to be symbolized by McLuhan's iconic statement “the medium is the message” ([1964] 1994).

If Innis is generally credited as the intellectual pioneer behind materialist approaches to media (he was, indeed, a generation older than McLuhan and one of his main sources of inspiration), McLuhan is instead commonly described as its advocate and defender (he was a public figure and whose books sold millions of copies worldwide). However, the two took quite different approaches to media technologies. While Innis was mainly interested in macro-level analysis (reflecting

⁸ In particular, Innis distinguished between the ‘bias of space’ (i.e., the means by which media enable control over territories) and the ‘bias of time’ (i.e., the means by which media endure across history). Distinct but interrelated, Innis saw these biases as having a profound impact on social development. Relatedly, McLuhan separated between the degree to which media engage and evoke participation in audiences, framing these as either ‘hot’ and ‘cool’ biases in media.

on the impact of media technologies in the rise and fall of empires and civilizations), McLuhan instead conducted his studies on a micro level and drew attention to the bodily effects of media (exploring their impact on human perception and cognition). In McLuhan's reading, media were seen as extensions of man and entities that widened the sensory scope of human beings. Innis was more concerned with how communication technologies induce large-scale social transformations, for instance by regulating the ease with which messages can be transported across space and time.

The thoughts of Innis and McLuhan have retroactively been referred to as 'medium theory' and unapologetically encourages close studies of the mechanisms, materials, and functions of media technologies.⁹ This approach is picked up in this dissertation, along with Innis's and McLuhan's broad and permitting attitude towards what counts as media. Innis—who began his research in the 1920's—adopted a wide conceptualization of communication systems which included transportation infrastructures (roads, railways, river beds), as well as commodities (fur, fish, paper, and timber).¹⁰ Thus, he highlighted the role of things, nature, and infrastructures in shaping communication. Innis's core reasoning was that roads (as well as pulp, for example) constitute means by which ideas and messages circulate. Thereby, he also perceived them as fundamentally integrated into communication systems. In similar ways, McLuhan defined objects such as light bulbs as media technologies, since they enable communicative practices by lighting up rooms and reducing darkness ([1964] 1994). Here, media technologies emerge as a broad collection of inventions and apparatuses that facilitate social interaction and allow information to be stored, accessed, processed, and disseminated.

Along this line of thinking, media research does not have to be limited to studies of '*the media*' (as in media conglomerates) but may instead be expanded to also

⁹ The term was introduced by Joshua Meyrowitz in the book *No Sense of Place* (1985). With it, Meyrowitz primarily sought to separate Innis's and McLuhan's work—which paid attention to the historical and cross-cultural "environments created by different media of communication"—from studies that focus on media messages (ibid., 16). Meyrowitz also adopts a materialist and non-content centered approach to media himself as he, for example, sets out to study how television has brought about substantial societal changes without analyzing one single television show (ibid.).

¹⁰ See for example (Innis 1925; [1930] 1973; [1940] 1978; 1950)

consider what Matthew Fuller and Andrew Goffey (2004) has described as “gray media”—mundane and rarely noticed media technologies that operate behind the scenes of the information economy and perform background operations or maintenance work. I regard the software technologies studied in this dissertation as examples of such ‘gray media.’ Built to discreetly generate knowledge about music in order to power music recommendations (in the case of the algorithmic music recommendation engine studied in article I), effectively facilitate the transmission of streamed music (in the case of the TCP/IP protocol studied in article II), contain music and keep it in place (in the case of the playlist format studied in article III), and unobtrusively identify copyright protected music online (in the case of audio fingerprint technologies studied in article IV), the software solutions explored in this dissertation have all been designed to regulate the dissemination of music without gaining unwarranted attention. They are ‘grey’—hidden, mundane, or designed to go unnoticed—but nevertheless powerful material entities that govern how music moves.

By building on—and expanding—Innis’s and McLuhan’s materialist media theories, this dissertation aligns with a recent re-orientation towards materiality in media studies. During the last decade, media scholars have repeatedly argued for a need to once again get closer to machines to understand their role in everyday life (e.g., Gillespie, Boczkowski, and Foot 2014; Parks and Starosielski 2015). I say ‘re-orientation’ and ‘once again’ since Innis’s and McLuhan’s focus on materiality largely fell out of fashion within media and communication studies in the 1970s and 80s. Instead, the field took a cultural turn where the study of social practices was privileged over the detailed analysis of media artifacts.¹¹ Heavily influenced by the Birmingham School and thinkers such as Raymond Williams—who fiercely critiqued McLuhan for being deterministic and ignoring the social practices that surround media¹²—this implied that media scholars mainly came to adopt hermeneutical, interpretive, and social constructivist approaches to media that centered on its *users* or *producers*, rather than the technical and physical specificities

¹¹ For an extended discussion of the lack of attention to technology and materiality in media studies, see for example (Frabetti 2015; Lievrouw 2014).

¹² See (Williams 1990, 122).

of media formats as such.¹³ Given that the 1970s and 80s constituted essential years in the formation of media studies as an academic discipline, one might even say that in many areas across the world, the field of media and communication studies developed a certain ‘blindness’ to media technologies themselves (Hyvönen, Snickars, and Vesterlund 2018).

By bringing materiality back into view, this dissertation offers a much-needed alternative to this hermeneutical tilt in media studies. I am sensitive to the fact that McLuhan’s media theory has been critiqued for being apolitical (since it repeatedly avoids discussing political and ethical issues), techno-deterministic (since it privileges technology over culture), and hardware utopic (since it shows a disproportionate faith in technology) (e.g., Durham Peters 2009; Geoghegan 2013; Gitelman 2006; Krämer 2006). Yet, I am also convinced that if we are to identify some of the major challenges and power struggles that media present today, there is a dire need to ask critical questions about the role of technology in governing information flows, directing online attention, evaluating data, and regulating the dissemination of ideas. This, I believe, also necessitates a materialist framework to pinpoint, problematize, and identify the key political issues that digital media introduce into everyday life.

As a response to the critique against McLuhan’s materialist media theory, it is also important to stress that my materialist considerations of media do not deny technology’s social and cultural dimensions. On the contrary, I see media technologies—and computer technologies in particular—as fundamentally cultural and political entities. Hence, I fully agree with Matthew Fuller who argues that digital technologies are “as open to theoretical cultural exploration as ... architecture, sexuality or economics might be” (2017). In other words, my approach to software technologies is grounded in the idea that there is no opposition between culture

¹³ For instance, such studies came to explore how people ‘create,’ ‘interact,’ ‘express themselves,’ and construct ‘meaning’ and/or ‘identities’ through media. Focus also largely came to be placed on the analysis of the *messages* that circulate in media, such as studies of how gender and sexuality is represented in public television or radio broadcasts. This emphasis on *text*, *content* and the *users* of media persists to this day and can, for example, be seen in media scholarship that studies “participatory” social media use (Jenkins, Ford, and Green 2013). As a result, the focus on materiality in media and communication studies has also been described as an unfinished project (Lievrouw 2014).

and technology; rather, the two are seen as inevitably entangled. Furthermore, it is precisely such entanglements that this dissertation seeks to explore.

My adoption of Innis and McLuhan's materialist approach to media has two significant theoretical consequences. First, it means that I reject the de-politicizing notion that the globalized network society is somehow 'virtual,' 'immaterial,' 'weightless,' and 'cloud-like.' Fueled by discourses around infinite storage and seamless online connection, the trope of immateriality has dominated contemporary conceptions of digital technologies and builds on the assumption that "digital stuff is weightless, supplied by unlimited resources and immune to decay" (Casemajor 2015, 4). Yet, as Innis and McLuhan remind us, media technologies are not abstract, free-flowing, and neutral communication channels—and this is true for digital and networked technologies as well. Digital media are cable networks that lie buried on ocean floors (Starosielski 2015), aerial satellite systems that orbit the earth (Parks and Schwoch 2012), large, heavy, metallic server halls (Holt and Vonderau 2015), and hard drives containing meticulous compositions of rare minerals and natural resources (Allen-Robertson 2017). Similarly, digital information is not an intangible force of symbolic meaning, but electric voltages, radio waves, and physical inscriptions on technical devices (Kirschenbaum 2008; Blanchette 2011). These voltages, waves, signals, and inscriptions are admittedly not easy to see, hear, or touch but they are fundamentally material nonetheless—and a materialist theoretical framework can help us untangle their technical dynamics and societal impact.¹⁴

To call digital media material is thus to recognize their physical grounding but also acknowledge their *built* and *constructed* nature; that is, their dependence on design and pre-defined rules, codes, protocols, and standards. The main benefit of bringing such materialities to the fore is that digital technologies are also made susceptible to critique and accountability. As James Allen-Robertson puts it, "the attribution of immateriality [to digital media]... has situated it in a rhetoric of inevitability, as beyond human control and free from existing power structures" (2017, 457). A similar point can also be made about the use of natural metaphors to describe digital

¹⁴ For an example of research that shows how the materiality of digital information *can*, indeed, be revealed, see for example Shintaro Miyazaki's media-archeological work on 'algorithimics' which traces the auditory emissions of algorithms and network traffic (2016).

media, such as talk of online ‘streams,’ ‘tsunamis’ of data, and ‘media ecologies’ (e.g., Puschmann and Burgess 2014). In similar ways as the trope of immateriality, this rhetoric runs the risk of depicting digital technologies as natural or given—an outside force that cannot be critiqued, controlled, or be held accountable for anything. A materialist framework, on the other hand, inevitably brings digital technologies back to earth and provides a structure for questioning their physical constitution and design.

Second, my choice to adopt a materialist approach to media implies that I resist anthropocentrism in the study of media and recognize that digital matter and technologies interfere with the world and must therefore be taken seriously as agents in shaping it. One of the most central ideas in McLuhan’s thinking, for example, was that the channels (i.e., media) through which human messages travel introduce fundamental changes to human affairs; a perspective which suggests that human beings are not alone in interfering in processes of communication. To adopt a materialist approach to media involves acknowledging that humans are not unaffected by the physical objects and technical systems that surround us. This is not to say that humans cannot resist the influence of technologies and that their power is absolute, but to recognize that we are bound to relate to physical matter in one way or another. Paying attention to materiality involves asking questions about the frameworks of action—or, to borrow from Innis and McLuhan, the biases—that media technologies instantiate. In this dissertation, I therefore explore what digital technologies *do* within digital markets for music: how they arrange objects and subjects in space and time and with what effects.

Kittler’s media materialism

One theorist who has extended Innis’s and McLuhan’s insistence on the materiality of media has been especially important in my work: Friedrich Kittler—one of the key figures in German media theory. In line with Innis and McLuhan, Kittler’s media materialism encourages close engagements with technical devices and suggests that what counts are not the messages or content of media, but rather their circuits and technical composition. Importantly, however, Kittler took an even more radical approach to materiality than Innis and McLuhan, arguing that media are not *extensions* of man (as McLuhan would have it), but rather entities that create

the very basis from which cultural expressions emerge.¹⁵ In short, Kittler saw media technologies as *prior* to any meaning that humans develop. Consequently, he was also convinced that there could be no ‘man’—as in human minds or intellects—if it were not for media. In line with this idea, Kittler rejected the notion that technology is only relevant to the extent that it is useful or meaningful for people. Instead of focusing on how technology is socially used or produced or perceived, he therefore paid attention to how media make thoughts, actions, and meanings possible in the first place. This approach involves seeing technology as a “driving force behind cultural life, rather than a controllable outcome of, so-called ‘social action’” (Gane 2005, 38). Here, media technologies emerge as entities that directly interfere with the world and carry their own ontologies and epistemologies.

Kittler’s radical materialist approach puts media technologies at the center of attention and has equally been described as deeply techno-deterministic—and pioneering—in terms of forwarding a post-humanist attitude towards media technologies and machines (Gane 2005). Kittler strongly emphasized that media has powers that lie beyond human control and even went as far as to bracket humanity as a distinct social category when using phrases like ‘so-called Man’ or ‘der sogenannte Mensch’ (Kittler 1999, 16). In particular, Kittler argued that “the age of media... renders indistinguishable what is human and what is machine” (ibid., 146) and was determined to challenge the idea that the human species is in complete control over technology. Kittler arrived at these ideas by drawing from psychoanalysis (and the writings of Jacques Lacan), communication theory (as developed by Claude Shannon and Warren Weaver), and especially Michel Foucault’s work on discourse theory.

Of particular relevance to this dissertation is Kittler’s (1990) work on discourse that transports Foucault’s ideas around discursive power into the technical domain. Foucault (2002) understood discourses as institutionalized patterns of knowledge that establish a foundation from which human action and thought become possible. In Kittler’s reading, this capacity is extended to machines, so that technologies are seen as able to guide—or in, some of Kittler’s most provocative formulations,

¹⁵ At one point, Kittler bluntly critiqued McLuhan for anthropomorphizing technologies by viewing them as extensions of man, calling such a depiction an “anthropocentric illusion” (Kittler 1986, 166).

determine—ways of being, acting, and thinking (1990, 232). Kittler described this move as an effort to correct an apparent flaw in Foucault’s theory of discursive power, namely his negligence towards the sources, channels, and receivers through which discourses materialize. As Liam Cole Young later put it, Kittler argued that there could be “no discourse without pens, paper, and typewriters, no archives without recording media and address systems, no governmentality without files” (2015). In Kittler’s view, things such as power, knowledge, thought, language, and subjectivity all emerge from—and are conditioned by—the systems that store, process, and transmit signals and information.

To think about media technologies along Kittler’s mode of thinking involves seeing technologies as powerful discursive entities that shape thought and action. As previously mentioned, I refrain from viewing media technologies as devices that introduce irrevocable changes into culture. However, Kittler’s ways of conceptualizing media as a backbone that carries the power to interfere with the world and creates a basis for human thought and action is important in my work. Kittler’s ideas are also significant for me since they bring Innis’s and McLuhan’s materialist theories into the digital domain and ask questions about the specific transformations computer technologies introduce into culture. While Kittler once famously argued that “there is no software”—a statement that sought to declare that software is fundamentally inseparable from hardware (Kittler 1995)—his ideas have influenced much contemporary research regarding software and its ways of guiding human action (e.g., Parikka and Feigelfeld 2015).

In particular, Kittler highlights how the power of digital technologies manifests itself through the layered and hidden processes of computers (1995). Since code operates invisibly in the background of digital devices, Kittler saw the transition into a digital media system as resulting in a fundamental loss of power and control. This is because computer technologies are often designed to alienate users from grasping their inner technical structures and operations—and thereby also deprive them of the ability to critique them. When writing with a pen and paper, for example, Kittler notes the process of inscribing a message is fairly transparent and visible to the naked eye (*ibid.*). When writing in a word processor, however, thousands of micro-processes take place below the screen; processes that are often difficult to fully grasp or see, even for those with advanced computer skills. When dealing with the layered processes of digital technologies, Kittler thus notes that “we

simply do not know what our writing does” (ibid., 148).¹⁶ For the same reason, he also despised the introduction of user-friendly interfaces that “hide a whole machine from its users” (ibid., 151).

Consequently, Kittler highlights the powerful concealment that characterizes digital technologies; a remark that encourages studies that explore how such invisible forms of power manifests itself. I share Kittler’s fascination with how digital media discipline and control both subjects (artists, music fans) and objects (recorded sounds) and place focus on the hidden and programmable decision-making processes that were introduced when music distribution became digital. In article IV, for instance, I discuss the role of software in domesticating and controlling recorded music when studying how audio fingerprint technologies make sound identifiable and intelligible to machines. In article I, I also highlight the role of software in measuring, evaluating—and thereby also governing—music and artistry when the logics of music recommendation engines are discussed.

Taken together, then, the media theories proposed by Innis, McLuhan, and Kittler provide a fertile theoretical framework for understanding media technologies as material entities that carry the power to shape communication and information. To adopt a materialist approach to media involves taking media technologies seriously as objects of study, asking detailed questions about their construction, composition, and ways of affecting culture. Rather than viewing media technologies as neutral channels through which messages move, a materialist framework highlights the constraints and possibilities that are inherent to media technologies and perceive these as capable of introducing fundamental changes into culture. Furthermore, a materialist framework suggests that the best way to arrive at—and disclose—such power dynamics is by carefully unpacking the material composition, formal rules, and operative functions of technical devices.

¹⁶ This line of thought has for example also been picked up by Wendy Chun in the book *Programmed Visions* (2011) and Bernard Stiegler, who argues that technologies exhibit a ‘deep opacity.’ As Stiegler eloquently puts it, “we do not immediately understand what is being played out in technics, nor what is being profoundly transformed therein, even though we unceasingly have to make *decisions* regarding technics, the consequences of which are felt to escape us more and more” (Stiegler [1994] 1998, 21).

Software studies

If materialist media theories provide a broader theoretical framework and argument for getting close to media technologies to study their logic, function, and composition, the field of software studies provides a particularly relevant framework for conceptualizing the material properties of the building blocks of digital media: code, algorithms, and software. Scholars in the field of software studies start from the realization that software has become a critical mechanism that regulates everyday life. Therefore, they also emphasize the need to understand and study how software organizes social interaction and affects ways of thinking, acting, and being (e.g., Beer 2017; Fuller 2008; Manovich 2013). While it is possible to find examples of humanistic and social science research that pays critical attention to computer technologies already in the 1980s,¹⁷ the term ‘software studies’ was first coined by Lev Manovich in the book *The Language of New Media* (2001). Initially, Manovich described software studies as an attempt to understand the logic of digital technologies by turning to computer science and the study of the characteristics of programmable media.¹⁸ Drawing from media theoreticians such as Innis, McLuhan, and Kittler, Manovich set out to “scrutinize the principles of computer hardware and software, and the operations involved in creating cultural objects on a computer” (ibid., 36).

In particular, Manovich studied how digital technologies bring with them particular ‘aesthetic opportunities’ and establish new representations of reality and visual culture. The aim of Manovich’s approach—and those who have followed him—has been to uncover the cultural logics at work within software, studying how software guides and/or replicates human action and thought. Thus, scholars in the field can be described as being concerned with the “conjugation of culture and computing” (Fuller 2017). They have also broadly studied the role of software in *shaping*—and being *shaped by*—social, cultural, and economic forces (Manovich 2013).

¹⁷ Here, Ted Nelson’s *Computer Lib/Dream Machines* ([1987] 2003) stands out, but other examples can also be found in the book *The New Media Reader* (Wardrip-Fruin and Montfort 2003a).

¹⁸ By then, software had of course already been ‘studied’ for a long time within the technical sciences, but not from a humanistic or social sciences perspective.

Today, the field of software studies is burgeoning and offers a framework for exploring the histories and politics of computer technologies, with a sensitivity geared towards issues such as power, culture, and economics. Apart from Manovich's writings, other early key works in the field include Nigel Thrift and Shaun French's writings on *The Automatic Production of Space* (2002), Noah Wardrip-Fruin and Nick Montfort's edited volume *The New Media Reader* (2003b), Matthew Fuller's *Behind the Blip* (2003), and Alexander Galloway's book *Protocol: How Control Exists After Decentralization* (2004).¹⁹ More recently, software studies have been picked up by academics in scholarly fields as law, sociology, history, geography, anthropology, philosophy, gender studies, literary studies, and science and technology studies.²⁰ The fact that software studies attract scholars from across the humanities and social sciences testify to the vitality and interdisciplinary of the field.²¹ It also attests to the broad conception that there is an urgent need to critically reflect on the role of software technologies in everyday life; an idea which this dissertation seeks to address.

Software studies scholars have previously approached software on a multiplicity of scales and levels, ranging from investigations into the intricate grammar of code (Berry 2008) to reflections on the protocols that govern transmissions of digital information (Dourish 2015), the formats that package and compress digital content

¹⁹ A second wave of key theoretical works in software studies appeared around 2006-2008 with Adrian Mackenzie's *Cutting Code: Software and Sociability* (2006), Matthew Kirschenbaum's *Mechanisms: New Media and the Forensic Imagination* (2008), and Matthew Fuller's edited volume *Software Studies: A Lexicon* (2008). Since then, Rob Kitchin and Martin Dodge's edited book *Code/Space: Software and Everyday Life* (2011), David Berry's *The Philosophy of Software* (2011b), Wendy Chun's *Programmed Visions: Software and Memory* (2011), and Lev Manovich's *Software Takes Command* (2013) have also emerged as key theoretical works within the discipline.

²⁰ See for example (Schuppli 2014; Burns and Lally 2017; Kockelman 2013; Frabetti 2015; Bivens 2015; Moats 2019).

²¹ As a result of the broad interest in thinking critically about software, a number of subfields within software studies have also started to emerge, including research known as *critical code studies* (Cox and McLean 2013; Berry 2008), *object-oriented software studies* (Caplan 2013; Fuller and Goffey 2017), and *platform studies* (Bogost and Montfort 2008; Gillespie 2017). Currently, the largest and most influential subfield of software studies, however, is most likely *algorithm studies* which problematize the role of algorithms in contemporary life (e.g., Kitchin 2017; Neyland and Möllers 2017; Cheney-Lippold 2017; Beer 2017).

(Sterne 2012), the algorithms that perform the micro-decisions that keep digital media moving (Kitchin 2017), and the interfaces that make up the immediately visible top-layer of computers (Drucker 2011). Of particular relevance to this dissertation is how software studies present a framework for defining and conceptualizing the different functions and characteristics of digital media. In what follows, I discuss five concepts that have been theorized in the field of software studies and that are also central to this dissertation: algorithms, code, and protocols, and software.

Algorithm, code, protocol, software

Algorithms are the building blocks of code, software, protocols, and platforms. In simplified terms, algorithms are often described as recipes that produce an output based on a series of predefined steps and instructions. In the context of digital media, an algorithm generally refers to a written sequence of alphabetical or numerical symbols that have been assembled to solve a computational problem. Among software studies scholars, however, the task of actually describing what an algorithm *is* has been intensely debated over the years. Countless articles have discussed the troubles—and dangers—of defining algorithms (e.g., Seaver 2013; Ziewitz 2011; Beer 2017; Gillespie 2014). What most scholars seem to agree on, however, is that algorithmic logics are at work in many different cultural domains and not just within digital media. For instance, all numerical mathematical formulae and sequential decision-making processes can be described as algorithms, since they are based on a pre-defined and step-by step logics.²²

In a digital context, however, Rob Kitchin recently made a useful attempt to describe algorithms, when he returned to computer scientist Robert Kowalski's 1970's definition of algorithms (Kitchin 2017; Kowalski 1979). Kowalski describes algorithms through the formula "algorithm = logic + control," where logic refers to "what is to be done" and control refers to "how it should be done" (Kowalski 1979). While this definition might seem straightforward at first, a closer look reveals that it can open up for considering the cultural dynamics of programming. In particular,

²² For an extended discussion on how humans sometimes behave like algorithms, see for example (Ziewitz 2011; Carmi 2019).

Kowalski's definition ultimately recognizes that algorithms carry cultural properties, i.e., that they are premised on the fact that someone has defined a *problem* and also expressed its *solution*. Without both of these components, an algorithm is incomplete and does not work. Given that algorithms are embedded in all digital media, the definition "algorithm = logic + control," thus opens up for a series of inquiries regarding how digital technologies prescribe a range of cultural ideas, logics, and norms.

From a critical perspective, algorithms have been framed as carrying social, political, and aesthetic dimensions, which call for studies of how they are crafted, developed, and used in the world. Software studies scholars have for example studied how algorithms govern both subjects and objects (Beer 2009), and express ideologies (Mager 2012), biopolitics (Cheney-Lippold 2011) and neoliberal logics (Chun 2018). However, it has also been stressed that algorithms are notoriously difficult to grasp. An algorithm rarely works in solitude and in the context of complex software systems, the full workings of algorithms are frequently not even clear to those who design and maintain them (Seaver 2013). This calls for carefulness when discussing algorithmic processes. Throughout the articles that make up this dissertation, I therefore reflect on the knowledge limitations that surround algorithmic systems, recognizing that algorithms—such as the ones powering the music recommendation engine studied in article I, or the audio fingerprinting system studied in article IV—are flexible, changeable and complex entities that are frequently modified and tweaked.

Code is an assemblage of algorithms. As Friedrich Kittler states in his contribution to the anthology *Software Studies: A Lexicon*, the use of codes (i.e., the mathematical mapping of symbols, signs, and letters into coherent sequences) is an ancient practice that dates back to the first alphabetical use of language (Kittler 2008). In the context of digital media, however, discussions about code generally refer to textual assemblages of algorithms that are compiled to instruct a computer to "do *something* to *something*" (Berry 2008 n.p.). David Berry, for instance, defines code according to its operative workings: "code," he writes, "produces a result" (Berry 2008). Computer codes are written in different programming languages and govern the operations of everything from complex computer programs to shorter scripts that perform single computational tasks.

From a software studies perspective, code has for example been studied according to its grammar (Berry 2008), gender biases (Bivens 2017), as well as aesthetics and political expression (Cox and McLean 2013). In this dissertation, I do not perform any close-readings of specific pieces of code, but rather study its outputs (when web-crawlers are scrutinized in article I) and reflect on its general functions and workings (when content filtering is explored in article IV). In article II (“The Editorial Playlist as Container Technology”), I also explore a specific description of code: namely the description of the coded or programmed playlist as a type of *container* for music. Here, the container metaphor is taken seriously and pushed to its boundaries, as I re-trace the connections between playlists and other types of analog containers such as bins, boxes, and baskets.

A protocol is a piece of code that standardizes and orders network communication. Alexander Galloway describes protocols as layered and stratified entities that enforce control and regulate interaction in the online domain (Galloway 2004, xvi). In a media-historical context, the figure of the protocol has also been explored by scholars such as Lisa Gitelman, who traces how not just digital—but also analog—media operate according to protocol logics; i.e., standardized and structured norms and rules regarding use (2006; see also Chun 2008). Currently, a wide range of important protocols are at work on the internet, such as the DNS protocol (Domain Name System) which governs the management of internet addresses and names, and HTTP (Hypertext Transfer Protocol) which governs the online workings of hyperlinks and mouse clicks, amongst other things.

As Galloway points out, protocols are political entities that establish power relations across digital media: they organize information flows and determine the basis for much of the social (and machinic) interaction that takes place online (Galloway 2004). In article II, I approach the Transmission Control Protocol/Internet Protocol (TCP/IP) which governs how information is horizontally distributed between computers across the internet. By following the paths along which streamed music content moves, this article highlights some of the politics of network traffic and uses a snapshot of a streamed music session as a starting point for discussing the multiplicity of global actors and material structures (data centers, cable networks) that are activated when streamed music moves.

The concept of software can be described as an umbrella term for assemblages of code and algorithms. Whereas algorithms, code, and protocols generally refer to specific segments or elements in digital technologies, software usually denotes a standalone computer program. A downloaded and installed Spotify app, for example, is a piece of software (which is built from algorithms, operates according to code, and carries affordances that are limited by protocols). I follow Adrian Mackenzie's call to understand software as performative; that is, as entities that carry productive powers and capacities to interfere with, maintain, subvert, and organize social life (2005). Software, Mackenzie argues, coordinates social action and is a carrier of cultural, ethical, and moral ideas; it is a material manifestation of norms, at the same time as it reproduces them (ibid.). In short, software guides actions through design: it carries an ability to *make things happen*. This is rooted in the fact that software is executable; it performs tasks based on encoded instructions (Galloway 2006). If we understand software as performative, then the critical question is not what software *is*, but rather what it *does*; how it changes things, how it renders reality in specific ways, and how it arranges the world. Hence, my work focuses on the operational logics of software—that is, its function and role within the music industries—and highlights how such operations are conditioned by material and cultural constraints.

To summarize, the field of software studies provides a framework for conceptualizing the material specificities of software, algorithms, code, and protocols—some of the main objects of study in this dissertation. Software studies includes research that traces the connections between culture and computing on a broad variety of levels ranging from the deep source code that lies closest to hardware, to the haptic and immediately visible interfaces that users meet. By interrogating and asking critical questions about the logic, ideas, and norms that are embedded in software, the academic field of software studies thus provides a basis from which the power and politics of digital media can be explored. It is also a field of research that continues a materialist tradition in media studies and opens up for political and philosophical reflections on the role of software in everyday life.

Two themes in this dissertation

In line with the title of this dissertation, *Online Music Distribution and the Unpredictability of Software Logistics*, I develop research in the fields of software studies and materialist media research by presenting two themes that specify the role of software in governing musical flows. The first theme that cuts across my articles concerns the logistical role of software; i.e., the role of software in arranging and coordinating the movement of people and property in space and time (Durham Peters 2013). I argue that a logistical approach is particularly useful for highlighting the calculative and bureaucratic logics at work when software is given the power to regulate music online. Hence, this section presents a framework for considering logistics as a specific mode through which software exerts power and influence over musical practices in the online domain.

A second theme that this dissertation accentuates is the unpredictable events that are triggered when software systems are endowed with logistical power. In line with a tradition of scholarship that focuses on technical problems, glitches, and accidents (Frabetti 2015; Nunes 2011b; Parikka and Sampson 2009; Virilio 2007; Fuller and Goffey 2012), I argue that instances of surprise and unpredictability offer a useful entryway for grasping the functions and cultural underpinnings of software. I also argue that technological surprises and unpredictabilities raise important questions regarding accountability and responsibility with regard to the increased influence of software in everyday life and must therefore be accounted for in the study of digital technology. In addition to presenting a logistical theoretical framework, this section therefore outlines a framework for conceptualizing the surprising and unexpected in software governance.

Toward an account of software logistics

In different ways, the articles in this dissertation point toward the logistical role of software; that is, the role of software in arranging and coordinating people (artists, music fans) and things (data, music recordings) within the online music industries. For instance, article I (“Close Reading Big Data”) studies how music recommendation engines intervene in—and manage relationships between—audiences and musicians by measuring and estimating the most desirable paths through which

music should be sent across the internet (i.e., recommended to users). In similar ways, article II (“Tracking Online Streams”), focuses on how software (and in particular, the TCP/IP protocol) regulates how music moves and is coordinated across the internet during an ordinary streaming session. Relatedly, article III (“The Editorial Playlist as Container Technology”) studies how the playlist format is used to arrange, assemble, and optimize the transport recorded music. In article IV (“In Pursuit of Musical Identifications”), the logistical role of software is also highlighted, as audio fingerprint technologies are put under scrutiny; a set of software solutions that identify, regulate, and logistically arrange how music moves and is commodified in the online domain.

Logistics, then, appears as a theme that cuts across the articles that make up this dissertation. But what is actually logistics and in what ways is a logistical framework useful for highlighting the role of software in governing musical flows? In political geography and science and technology studies—two academic fields where scholars have given logistics much thought—logistical operations have previously been defined as “the art and science of managing the mobility of people and things to achieve economic, communication, and transport efficiencies” (Neilson 2012, 322). The etymology of the word logistics can be traced back to the Greek *logistikos*, which means “skilled in calculating” (Cowen 2014, 26). Historically, logistics has origins within the military where it concerned strategic work related to the management of troops and army inventory (ibid.). Within fifteenth-century imperialist conquests, for example, logistics involved the careful tracking and monitoring of ships as they were sent across the earth (Law 1986), and during the Napoleonic wars, the word *logistique* referred to practices concerned with deploying “men and matériel” to the front lines (Cowen 2014, 620). Often tied to the controlled surveillance of space, time, objects, and bodies, logistics has in short been a central concern in empire-building and state control.

Since the Second World War, however, the field of logistics has migrated beyond army borders and into civilian and corporate domains, where it has come to play a key role in capitalist development (ibid.). In global markets, logistical operations deal with the optimization of the transportation of goods to reach financial gains; a process that has become significantly more advanced thanks to digital technologies and their capacity to monitor labor, production, and distribution in global commodity chains (Kanngieser 2013; Rossiter 2016). From a critical perspective,

logistical operations have been described as a means of exerting long-distance control; i.e., monitoring and controlling subjects and objects from afar (Law 1986). It has also been described as a “calculative rationality and a suite of spatial practices” that are underpinned by “structures of governance, exploitation, dispossession, and domination” (Chua et al. 2018).

As part of global capitalist systems, logistical operations have especially been associated with technocratic, bureaucratic, and calculative endeavors involving extensive practices of surveillance, statistical modeling, experimentation, and risk management. In Henri Lefebvre’s reading, for example, logistical practices are concerned with making space and things commensurable, that is, “equivalent, exchangeable, [and] interchangeable”; a task that generally involves reducing things into numbers, quantities and replaceable entities (Lefebvre 2009, 233). To summarize, logistical operations thus encompass deeply calculative rationalities and a wide range of strategies and techniques that are oriented towards establishing control, oversight, and power.

I argue that the tasks performed by the software technologies studied in this dissertation can be described as logistical since they are ultimately aimed at controlling, ordering, and establishing oversight over how music moves online. When calling these software technologies logistical, I draw from the previously mentioned conceptualizations of logistics, but also the work of John Durham Peters, who introduces the concept of *logistical media* to describe how media technologies “arrange people and property into time and space” (Durham Peters 2013). Peters argues that logistical media have a clear organizing function: they guide our attention, orient us in the world, and often gain power through their means of appearing as neutral or given. In the essay “Calendar, Clock, Tower,” for example, Peters discusses how almanacs, watches, and towers can be considered as logistical media since they exert an underlying power and control in contemporary life (ibid.). Logistical media, he writes, “establish the central points around which culture rotates... [and] are prior to and form the grid in which messages are sent” (ibid., 41).²³

²³ Here, Peters is clearly evoking a Kittlerian take on media technologies, as they are described as entities that underlie ways of being, acting, and thinking.

Peter's conception of logistical media builds on theorists such as Harold Innis, James Carey, Lewis Mumford, and Paul Virilio; thinkers who understand "logistical media as subtle but powerful devices of cognitive, social, and political coordination" (Case 2010, 1). In the case of calendars, for example, Peters traces their religious lineage and political anchoring, showing how they are ultimately products of cultural design. Peters's notion of logistical media has been picked up by several scholars who have for example extended his ideas by considering the logistical role of lists (Young 2014), radar technologies (Case 2010), and software for tracking the whereabouts of workers and commercial resources (Rossiter 2014). In such works, media technologies are approached as devices that synchronize interaction and position subjects and objects in particular relations to one another, often with specific political ideas and goals in mind. These approaches to media do not least build on cybernetic ideas, where focus has historically been placed on machinic and environmental systems of communication and control (e.g., Wiener [1948] 1985). The cybernetician Ross Ashby once described cybernetics as a mode of inquiry into "the art of *steermanship*" ([1956] 1957, 1)—a description which I believe could equally be applied to a logistical approach to software and digital media technologies.

While the software solutions studied in this dissertation were not always framed as *logistical* in the actual publications (and will probably lack the permanence of logistical media such as clocks and calendars), I argue that logistical rationalities are at work in all of them. By framing music recommendation engines (article I), the TCP/IP protocol (article II), playlists (article III), and audio fingerprint technologies (article IV) as logistical, I want to highlight two things. First, I want to emphasize their commercial, calculative, and mathematical role in facilitating circulation and distribution; aspects which I believe are particularly relevant for understanding the role of software in organizing movements of music online. Logistics is concerned with economic and calculative rationalities; reducing objects and subjects into numerical figures which can be measured, re-arranged and experimented with, often in the interest of increasing financial profit. This, I argue, is precisely the role that software frequently plays in digital music distribution. For instance, article IV ("In Pursuit of Musical Identifications") shows how audio fingerprint technologies (and especially YouTube's Content ID system) facilitates content-based systems of copyright surveillance that are grounded in practices of making sounds calculable, measurable and identifiable. Likewise, article I ("Close Reading Big Data") illustrates the role of algorithms in detecting, ordering, and

arranging music and artistry by quantifying and measuring things such as the ‘hotness’ of artists; the results of which are later fed into music recommendation systems and thereby governs how music moves at scale. By framing these technologies as logistical, I want to stress their fundamental rootedness in calculative and commercial practices.

Second, a logistical framework has the benefit of bringing together administrative and bureaucratic perspectives on distribution and circulation (Young 2014, 127). As scholars like Max Weber ([1968] 1978) have shown, bureaucratic and administrative work is concerned with establishing and upholding rules, laws, divisions of labor, and organizing chains of command. It is also concerned with rationalizations, enforcing system efficiencies, and establishing uniform systems of measurement and control (ibid.). These types of bureaucratic and administrative tactics are also central to the tasks performed by the software solutions studied in this dissertation; software technologies that are deployed to carefully oversee, codify, regulate, direct, classify, economize, and keep track of musical flows. By calling the software solutions studied in this dissertation logistical, I thus seek to underscore their fundamental rootedness in bureaucratic and administrative logics. For instance, article III (“The Editorial Playlist as Container Technology”) shows how the mundane playlist format establishes a uniform container for tracks which opens practices of listening to various forms of economic optimization (connecting listeners to advertisers and extending the shelf-life of tracks, for example). In similar ways, article II (“Tracking Online Streams”) shows how the TCP/IP protocol is responsible for establishing rules, divisions of labor, and system efficiencies with regards to complex networks of actors in digital music distribution (content delivery networks, data centers, internet providers, etc.). In so doing, these articles also point towards the managerial role of software and its ways of facilitating order, oversight, and control.

To summarize, I argue that the software technologies studied in this dissertation play a central role in organizing, arranging and sorting subjects (artists, fans) and objects (music files)—which also means that they can be understood as logistical devices. A logistical perspective on software has the benefit of highlighting its calculative and bureaucratic role in arranging the movement of online music; two roles which I argue are central to software’s ways of making an impact within the music industries. By approaching software technologies through a logistical lens,

attention is drawn towards the media technologies that “orient us in space and time”; the technologies that frequently appear as apolitical but continuously index and make important choices regarding how objects, subjects, and information are positioned in the world (Kane and Durham Peters 2010). In doing so, a logistical lens also reminds us of the empirical necessity of paying attention to “nuts-and-bolts distribution functions” (Bonacich and Hardie 2006) and their ways of shaping relations between people.

Unpredictability in software governance

If the logistical role of software is one important theme in this dissertation, a second topic that cuts across my articles concerns the disturbing, unexpected, and/or irregular events that are triggered when software technologies are given the power to intervene in musical flows. For instance, article I (“Close Reading Big Data”) highlights how web-crawlers capture odd and peculiar data from the web, article II (“Unpacking Online Streams”) shows how machines fail to communicate and engage in anxious and excessive greetings when music content is streamed, article III (“The Editorial Playlist as Container Technology”) explores how instances of fraud and manipulation occur around playlists, and article IV (“In Pursuit of Musical Identifications”) interrogates how automatic content identification systems produce strange identifications of sound.

By accentuating such moments of surprise, disturbance, and unpredictability, I seek to address the flip-side of the calculative and bureaucratic mechanisms that logistical operations entail: their ways of also causing choke-points, blockages, unsettlement, and rupture (Alimahomed-Wilson and Ness 2018; Chua et al. 2018; Klose 2015). At the same time as logistics can be understood as an art of control and surveillance, logistical operations carry with them haphazard accidents and vulnerabilities.²⁴ In this way, logistics should not only be understood as a set of practices and techniques that successfully facilitate and control mobility, but also something that creates

²⁴ For instance, scholars like Alexander Klose have shown how logistical operations are frequently plagued by sabotage (Klose 2015), while Nicky Gregson has emphasized the tendency for queues, frictions, and congestions to arise in logistical chains of transportation (Gregson 2017).

disturbances, frictions, and *immobilities* (Birtchnell, Savitzky, and Urry 2015). In this dissertation, I consequently choose to highlight the backside of logistics—it’s ruptures, blockages, and tensions—by discussing the awry, odd and surprising events that software triggers in online music distribution.

There are three primary reasons why I want to do so. First, I believe that technical ruptures must be seen as *inherent* to technologies. This implies that critical reflections on technology must also take instances of failure and rupture into account, rather than ignoring them.²⁵ As Paul Virilio notes, technical breakdowns, disasters and/or mistakes are part and parcel of technology and events that reveal the unavoidable *potential* for accidents that is inherent in all technologies (2007). Hence, Virilio fittingly notes that “to invent the sailing ship or the steamer is to *invent the shipwreck*. To invent the train is to *invent the rail accident* of derailment. To invent the family automobile is to produce the *pile-up* on the highway” (ibid., 10). In other words, Virilio highlights how technological accidents should not be seen as abnormalities but rather fundamental parts of the technological condition. Accordingly, I argue that technical surprises and failures must also be accounted for in studies of software, and consequently choose to highlight such instances throughout my work.

Second, I argue that instances of surprise and unpredictability in software can play an important role in problematizing instrumentalist approaches to technology; i.e., the notion that technology is always under our control. At their core, instrumentalist approaches to technology are grounded in “the Aristotelian idea that technology is a tool that must be mastered by humans to produce certain ends” (Frabetti 2010, 128). This idea—which ultimately positions technology as an object of human domestication—has laid the groundwork for the general understanding of technology in the Western philosophical tradition (ibid.). It has also been central in the development of modern conceptions of technical ‘progress’ and played a key role in legitimizing the increased adoption and influence of digital technologies in everyday life.

²⁵ Notably, accidents, frictions, and errors are for example rarely mentioned in the works of Harold Innis, who frequently portrays ‘perfect’ communication systems that work according to plan.

Yet, in contrast to the view that software is fully under our control, technological unpredictabilities, fallibilities, and surprises constantly emerge within and around software (and technologies writ large).²⁶ While technologies often function remarkably well and seem to follow our lead, it is—as Virilio notes—also true that ships run aground, trains derail, and cars crash. To highlight such moments of technological rupture and surprise problematizes the idea that software is a fully governable entity whose risks can always be anticipated and avoided (Frabetti 2015). Hence, I use instances of technical surprise and breakdown as an entryway for raising questions about accountability and to question the utopian and overly techno-optimistic discourses that frequently surround digital media. In accounting for technical unpredictabilities, I want to highlight the fragile and sometimes uncontrollable aspects of the software that logistically governs musical flows.

Third, I suggest that technical failures are analytically productive moments that can help us gain insights about the logics and power of software. As Federica Frabetti puts it, technology is often “most revealing precisely when it does *not* work—or, even better, when it is unclear, to common users and even to technical experts, *whether* it is working or not” (Frabetti, 2010: 110). Sometimes, instances of breakdown and/or confusion can tell us more about the logic and power of technologies than situations when they work. This has long been known by scholars in the field of science and technology studies (e.g., Bowker and Leigh-Star 1999) and media archaeology (Huhtamo and Parikka 2011). Here, moments of rupture have been approached as key sites where technical devices and infrastructures—that otherwise frequently remain unnoticed or hidden—open themselves for critical analysis. For instance, we do not reflect on the influence and power of waste management systems until they suddenly stop working (Kallianos 2018). Similarly, we tend to ignore the influence and power of algorithmic content filters—such as YouTube’s Content ID—until it suddenly declares homemade videos of purring cats as copyright abuse (article IV). When technologies break down or misbehave, they make themselves—and their power—immediately felt. Accordingly, I approach technical instances of breakdown or surprise as productive analytical moments that advance insights into the role of software in digital music distribution.

²⁶ This has not least been stated by Jacques Derrida, who sees unforeseen consequences as implicit in technology. For more on this, see (Frabetti 2010, 2015).

To recapitulate, I thereby argue that discussions regarding the unpredictable outputs of software technologies are not only necessary (since failures are inherent to technologies and must therefore be accounted for), but also analytically productive (since they can provide privileged insights into the workings and power of technology). Furthermore, I argue that surprising and/or disruptive elements in software are useful for problematizing instrumentalist approaches to technology and questioning dogmatic notions of linear, technological progress. By highlighting moments of technical discontinuity, I want to problematize grand narratives of technological ‘success’ and instead show how technical development is often ridden with accidents and failures. This is done in order to formulate a more nuanced perception of digital technologies and their ways of governing information flows.

When focusing on instances of surprise and unpredictability in software governance, I build on the previously discussed academics (Virilio, Frabetti, Bowker, Star, Parikka, Huhtamo) but also a wide range of media scholars who have recently explored various types of digital surprises and mischiefs, highlighting how technical systems do not always behave as planned. Research that focuses on instances when digital media ‘go awry’ include Mark Nune’s (2011) writings on digital errors (where errors are described as a form of technological wandering from the predictable confines of information control), Matthew Fuller and Andrew Goffey’s (2012) work on “evil media” (which depicts the ‘evils of media’ as the sudden display of the manipulation-prone nature of networked technologies), and Jussi Parikka and Richard Sampson’s (2009) research on computer viruses (that describes ‘anomalous’ digital events as those who deviate from conventional or idealized notions of what technologies should do).²⁷ While each of these scholars frame and discuss digital ruptures differently, they all assert that technological fallacies provide a particularly useful starting point for grasping the role of technology in everyday life.

²⁷ Notable here is also Finn Brunton’s research on spam (2013), Jonathan Zittrain’s writings on the generative features of digital technologies (2006), Luciana Parisi’s research on ‘computational contagion’ (2013), Olga Goriunova and Alexei Shulgin’s writings on digital ‘glitches’ (2008), Matteo Pasquinelli’s anthology on augmented intelligence and its traumas (Pasquinelli 2015), and Peter Krapp’s explorations of communication disturbances and inefficiencies (2013).

In article II (“Unpacking Online Streams”), for instance, I discuss how instances of surprise and unpredictability challenge the conventional and idealized notion that streamed content transmissions are friction-free. By highlighting streamed communication blockages and network redundancies, this article paints an alternative picture of streaming services and problematizes notions of calm and steady streams. My investigation shows how streamed content transmissions are messy and dirty technical processes where data gets stuck, piles up, and is sometimes passed on to unknown actors (such as online advertising brokers) in obscure and opaque ways. Thereby, it also highlights the ruptures that are inherent in technological systems (Virilio 2007) and problematizes corporate descriptions of digital technologies as transparent, smooth, and efficient.

In article III (“The Editorial Playlist as Container Technology”), I instead pick up on the work of Matthew Fuller and Andrew Goffey, who are interested in “the unintended or secondary effects of media” and study how “mediation facilitates and amplifies the creation of troubling, ambiguous social processes, fragile networks of susceptible activity, [and] opaque zones of nonknowledge” (Fuller and Goffey 2012, 2–3). Fuller and Goffey call such ambiguous troubles and secondary effects “the evils of media,” and sees networked infrastructures (such as telecommunication systems and satellite infrastructures) as carrying a materiality that is inherently “labile and mutable and [therefore] offers diverse opportunities for manipulation, modulation, and control” (ibid., 15). Along these lines of thought, article III explores some of the ‘evils’ of the playlist format. In particular, it discusses the uncanny elements that are found within and around editorial playlists for music: manipulations, scams, and murky acts of musical smuggling. Here, my discussions around technical unpredictabilities center on instances where others (primarily music fans and music journalists) have expressed disappointment and sometimes anger against the types of actions that take place around playlists. By drawing from a series of events that caused unsettlement within the music industries—the discovery that Spotify was embedding ghostly and anonymous music into some of its most popular playlists, and a sequence of news regarding manipulations of playlist plays—the article highlights how trickery and deception is a central element in the distributive practices that surround digital music. In doing so, it also problematizes the image of the playlist as a safe container for tracks and highlights how digital music packages give rise to exploitation, turbulence, and fraud.

Taken together, then, this dissertation presents studies that highlight how the actions and outputs of software strive towards the unpredictable, evil, or surprising. I approach the unpredictable in software as events that challenge or escape expectations, goes astray from intentions, and thereby lays bare the fragility and/or manipulability of digital technologies. I also approach technical unpredictabilities as inherent elements in network architectures, rather than bumps on the road towards technical perfection. Whether it concerns reflections on digital trash and technological curiosities (article I), flawed and incomprehensible machinic speech acts (article II), playlist fakes, manipulations, and safety disappointments (article III), or algorithmic misjudgments of sound (article IV), I choose to talk about the unpredictability in software governance in order to highlight that software (contrary to instrumentalist perceptions) is habitually unstable and full of friction.

Importantly, such a discussion is not meant to curtail human agency and accountability. On the contrary, I maintain that the actions of software are always ultimately a human responsibility—even if its effects and behaviors cannot be fully anticipated. Software technologies may behave in unexpected ways, but they are always products of human design and the responsibility of those who uphold, maintain, and allow them to do work in the world. In line with Federica Frabetti, I therefore argue that the unexpected outputs of software raise questions about accountability—not in the sense that programmers who build erroneous software systems have ‘failed’ and should have done a better job in software engineering—but rather in the sense that unpredictabilities are inherent to software technologies and must therefore always be accounted for when software is given the power to intervene in the world.

3. Methodological framework and materials

Algorithms and software technologies are slippery objects of study that frequently remain invisible and operate in opaque and hidden ways. This poses several methodological challenges that I argue can be resolved by maintaining an openness towards exploring new methods and techniques for obtaining and analyzing data. Accordingly, this dissertation calls for a mixed-methods approach in the study of software technologies and weaves together three methodological approaches that explore the role of software in everyday life. These approaches include media archaeological techniques of ‘digging’ into the layered and sedimented technical strata of machines, the adoption of technologically oriented ethnographic methods that provide a framework for observing and interacting with digital technologies, and the use of experimental and digital methods. Taken together, I show how these three methodological approaches (digital methods, media archaeology, and techno-oriented ethnographic work) create a basis for *thinking through* software technologies and the relations, events, and forms of knowledge they produce.²⁸ In particular, I show how the combination of these three methodological approaches advance research in media and communications studies by developing a methodological framework that takes digital technologies seriously—both as objects of study *and* strategic research tools.

²⁸ The notion of ‘thinking through’ is borrowed from social anthropology and its methodological strategies of ‘studying through’ by tracing how power creates webs of relations in organizations and cultural settings (Shore and Wright 2006).

Digital humanities research and digital methods

The first methodological field that this dissertation contributes to is the digital humanities; an interdisciplinary research area that pulls together academics in fields such as archaeology, art history, linguistics, literature, philosophy, and not least media and communication studies. Put simply, DH-scholarship can be described as humanistic research that displays an orientation towards the use and development of digital methods. Since this is one of the methodological starting points adopted in this dissertation,²⁹ the following section provides an overview of DH-research and positions my research in relation to previous trends and tendencies within the field. Furthermore, it discusses how digital methods have been used in this particular dissertation, highlighting both the strengths and weaknesses of such approaches.

While the use of digital methods in humanistic research may seem novel, it builds on a long history of using computers in humanistic research. Computational technologies were adopted by scholars in the humanities already in the late 1940s and have followed humanities scholars until the present age, functioning as a tool for handling, filtering, and analyzing archives of data (Berry and Fagerjord 2017). It was not until the late 1990s, however, that the field which is now known as ‘the digital humanities’ started to evolve. Today, the use of digital methods is certainly not exclusive to scholars in the digital humanities (many academics in the humanities who use digital methods would not call themselves DH-scholars), yet digital humanities scholars have continuously and persistently explored new ways of integrating digital technologies into research practice. Thereby, the field also provides one of the most sustained and long-term reflections on the implications of using digital technologies in humanistic research.

Because of its disciplinary openness, however, the exact meaning of the digital humanities has been widely debated over the years (e.g., Bode and Arthur 2014; Gold 2012; Svensson and Goldberg 2015a). Many of those who have tried to provide an overview of digital humanities research have done so by dividing it into different stages or waves. While such attempts of periodization must always be taken

²⁹ My PhD position has had a digital humanities profile and in the past four years, I have been affiliated with Humlab, a digital humanities lab at Umeå University.

with a pinch of salt (time and interest-based overlaps of course exist, since scholarly interests rarely follow linear paths), they provide a useful overview of the different approaches and topics of interest that have characterized the scholarly field. Schnapp and Presner (2009), for example, make a distinction between first-wave DH research (which mostly deals with digitizing content), and second-wave DH research (which instead explores materials that are ‘natively digital’). The authors describe the first wave of digital humanities work as quantitative and engaged in “mobilizing the search and retrieval powers of the database, automating corpus linguistics, [and] stacking hypercards into critical arrays” (ibid., 2). This research often focuses on large-scale digitization projects and the establishment of infrastructures that can support advanced computations. It also still does, as large cultural heritage archives are continuously digitized across the world. The second wave of DH-research is instead described by Schnapp and Presner as “qualitative, interpretive, experiential, emotive, and generative in character” (ibid.) with a shift towards interacting with knowledge that is ‘born digital’ and lives in various digital contexts. Such digitally native materials might for example include Tweets, digital images, and user-generated video content.

Building on this periodization, David Berry has suggested that a possible ‘third wave’ within the digital humanities can be identified—one which is “concentrated around the underlying computability of the forms held within a computational medium” (2011a, 4). Such types of DH-research would not only *use* digital methods but also critically interrogate the underlying premises of digital technologies as such. Berry writes that “to understand the contemporary born-digital culture and the everyday practices that populate it—the focus of a digital humanities second wave—we need a corresponding focus on the computer code that is entangled with all aspects of our lives” (ibid.). Thus, third wave DH-scholarship may be described as a turn towards technological criticism (or software criticism) and the problematization of computational processes in themselves.

It is within this third wave of DH-research that I situate this dissertation. In the book *Digital Humanities: Knowledge and Critique in a Digital Age* (2017), David Berry and Anders Fagerjord assert the need for DH-researchers to take digital technologies seriously as objects of study and put forward the notion of a “critical digital humanities research” that aligns with the third wave DH-research previously identified by Berry. Critical digital humanities research, they suggest, serves to

“build theoretical understandings of computation in culture, just as much as humanists and media scholars have explored the role of writing, of image, and of the printing press” (ibid.). In other words, Berry and Fagerjord are calling for a merger between the digital humanities and software studies. A call is not a description of an already existing and thriving branch of DH-research, however, and critical reflections on software have often been absent from digital humanities research. As a result, DH-scholars have been critiqued for not paying enough critical attention to how technologies are deployed (Liu 2012), getting stuck in never-ending developments of digital tools (Lovink 2012), and falling into the trap of instrumentalist and overly techno-optimistic approaches to digital technologies (Drucker 2012). I continue Berry and Fagerjord’s efforts to counter the method-centrism and techno-optimism that is often present in DH-scholarship and seek to answer their call for a more critically grounded digital humanities research. In this dissertation, I therefore show how DH-research may involve both the use and exploration of digital methods *and* an effort to pay critical attention to the power and politics of software.

My use of digital methods can both be described as experimental attempts to analyze technology and culture, and as creative workarounds to the lack of access to resources that frequently haunts digital research (Svensson and Goldberg 2015b). As colleagues and I have argued elsewhere, the ‘black boxing’ of software technologies calls for the development of new and innovative ways of studying them, including the adoption of experimental methods that directly engage with technical systems to explore their workings (Eriksson et al. 2019). Importantly, such efforts are not meant to suggest that it is possible to fully ‘reveal’ and disclose some inner secrets or truths that lie hidden within technical systems. Rather, I adopt a cybernetic view on the ‘black boxing’ of digital technologies, where opacity and invisibility is understood as a fundamental technological condition (Ashby 1956). Along this line of thinking, it is recognized that it may not be possible to get to the core of what technologies are and how they function. Nevertheless, we can analyze and deduce what we can of their workings to better understand how technologies affect—and are affected by—the cultural and economic contexts in which they appear (ibid.). As Taina Bucher suggests, such a cybernetic approach focuses on understanding the relationship between technical systems and their environment, and searches for openings that allow us to see into technical systems—not least in order to map the things we *cannot* know about them (Bucher 2018, 60).

By using digital methods, interventions, and “tricks,” I have thus attempted to make software technologies reveal and describe themselves in situations where their workings would have otherwise remained hidden (Latour 2005, 79; Bucher 2018). I have also followed Richard Roger’s classic call to repurpose and re-use the “methods of the medium” in the study of digital culture (Rogers 2013, 1). In part, these methodological strategies have also been inspired by a reverse engineering approach; i.e., the practice of starting with a concrete technological object and/or its outputs and then working backward towards an understanding of how that object came to be (Gehl 2017).³⁰ Reverse engineering frequently involves breaking, dissecting, disassembling, and decompiling technical apparatuses to explore their mechanics and functions, including the ideas that brought them into being. In my research, however, I have not broken or actively decompiled anything and my use of the term should therefore be understood in a metaphorical rather than strictly practical sense.

Using API’s as Gateways to software

My use of digital methods in this dissertation has, for example, included the re-appropriation of an API to study the company The Echo Nest, which uses software and algorithms to extract ‘music intelligence’ from the online domain (article I). At its core, an API can be described as a structured entry to a digital source (commonly, an archive, platform or a database). By obtaining permission to use an API, a person is allowed to search and retrieve data from a digital source based on a predefined set of rules and queries. The history of Application Programming Interfaces (APIs) can be traced back to the 1980s when new principles of software design were needed to facilitate interoperability between different software systems (Bucher 2013). Some of the first large IT-companies that offered open APIs were eBay (which did so in the year 2000), and Google and Amazon (who went public with their first APIs in 2002) (ibid.). Today, most online platforms provide an API that allows data and

³⁰ In the article *(Critical) Reverse Engineering and Genealogy*, Gehl (2017) traces the connections between Foucault’s genealogical approach and reverse engineering practices, noting that both seek to study how things, events, and modes of being, speaking, and thinking are formed. Gehl, however, calls for a “critical reverse engineering,” that does not stop at a critique of technology but also “*produce something better*” (ibid., 2). This is something that I cannot claim to have done.

services to be interconnected and built into each other. In particular, APIs facilitate the design of third-party applications that are built on top of other services, so that users can sign in to external applications using their Facebook ID, for example. As a general rule, APIs are made available precisely for this commercial reason: to encourage the development of applications that increases traffic (and data exchange) between platforms.

In my work, however, The Echo Nest's API was not used for app development but to study the logics and knowledge-making mechanisms of web crawlers and algorithmic systems for online data collection. The Echo Nest is a Spotify-owned company that continuously crawls the web in search of information about artists; information which it then analyses to estimate the 'popularity' or 'hotness' of musicians, for example. This information then powers music recommendation engines on Spotify and is saved in a database that can be accessed through an API. After obtaining permission to use The Echo Nest's API for research purposes, I used it to explore how the company collected metadata concerning 22 different musicians and composers during one month (March 1st–April 1st, 2015). This was done in collaboration with Fredrik Palm (system developer at Humlab, Umeå University) who wrote a PHP-script that ran every day at 7.30 am and automatically searched, retrieved and stored information from The Echo Nest's database.³¹

Equipped with this tool, I retrieved 1386 blog posts that The Echo Nest had collected about the selected musicians during the time-frame of the experiment. These blog posts form part of the content upon which The Echo Nest ranks, classifies, and values artists and thus provided a snapshot of what the company's data collection methods look like. Such a 'snapshot' is inevitably partial and bound by the specific context in which the data was collected (the specific artists that were chosen for the experiment, the specific point in time when the data was collected,

³¹ The extracted data was first stored in a JSON-format and organized into a database that connected the data to each artist and the date/time of capture. Since The Echo Nest's API only allows a restricted amount of requests for data per second, the PHP-script had a built-in delay in each request for data, so that the API's terms of use would not be violated. An external website that allowed for monitoring the data extraction was also put in place.

etc.). Yet the experiment provided a unique glimpse of how a market-leading company gathers and values online information.

In article I (“Close Reading Big Data”) the captured blogs were used as source materials and analyzed individually and manually according to their content. Since I was particularly interested in exploring what types of data The Echo Nest’s web crawlers were trained to detect—and what this data said about the company’s strategies of evaluating artists and musicians—the blogs were initially classified according to their content and relation to the artists they were meant to describe. As a result of this classification, the analyzed blogs were divided into three main categories, upon which the analysis in the article was later built. These categories included (1) blog posts where the musician, band or artist in question was in focus, (2) blog posts where the musician, band or artist in question was mentioned, and (3) what came to be called “rotted” blog posts. The latter category was made up of duplicates, dead links, or blogs that did not contain any information whatsoever about the artist it was meant to describe. When analyzing these blogs, one can thus say that I engaged in a close reading of the ‘big data’ The Echo Nest had collected from the web.

It is important to note that my use of The Echo Nest’s API differs from how API’s are frequently used in the (digital) humanities and social sciences—and especially in social media research. Here, API’s are often used to scrape/capture content such as Tweets, Facebook posts, or Instagram messages, which are then used to study people’s online communication patterns. This means that materials gathered through an API are treated as relevant source materials for gaining insights about social media use and online behaviors, rather than to study platforms such as Twitter, Facebook or Instagram in themselves. In my research, however, I did not treat the blog posts gathered through The Echo Nest’s API as a relevant source for gaining insights about music blogging. Instead, I used the blogs obtained through The Echo Nest’s API to study how The Echo Nest gathers, values, and presents online information. In other words, I used The Echo Nest’s API to study *The Echo Nest*, not music blogs as such.

Given the many risks involved in using data obtained through APIs, I argue that this approach represents a particularly useful—if not necessary—strategy for repurposing APIs as part of critical digital humanities research. As José van Dijk has pointed out, APIs are entities that specify “protocolized relations between data,

software, and hardware” and allow users to interact with archives and databases under specific predefined conditions (van Dijck 2013, 32). This means that API’s are not neutral gateways to data but entities that deliver highly curated forms of information. For instance, it is widely known that Twitter’s API (which has existed in multiple different versions) filters out many tweets and skews data towards network clusters that Twitter believes are relevant (Driscoll and Walker 2014; González-Bailón et al. 2014). For this reason, using the information obtained through Twitter’s API to gain insights about social media use is risky since it is often difficult to tell if information has been filtered out (Black et al. 2012; Lomborg and Bechmann 2014; Driscoll and Walker 2014; Bodle 2011).

In my research, however, I precisely set out to study The Echo Nest’s mechanisms of filtering and skewing data. In other words, the fact that the data obtained through The Echo Nest’s API may have been filtered and incomplete was not a limitation—but the core interest of the entire study. I did not assume that The Echo Nest’s collection of blogs would be able to tell me something relevant about music blogging (or the actual ‘hotness’ or ‘popularity’ of performing artists). What I did assume, however, was that the blogs obtained through its API could tell me something about how The Echo Nest gathers and values online information. In the end, the experiment provided a starting point for reflecting on the curious logics of web-crawlers and the normative implications and outcomes of algorithmic systems of expertise.

Packet sniffing on network traffic

Another digital method used in this dissertation involved experimenting with so-called packet sniffers (or Network Protocol Analysis tools) to capture and investigate the infrastructural entanglements that a single ‘click’ on Spotify generates (article II). Here, a so-called packet sniffer was repurposed as a research tool and used as an entryway for ‘listening in’ on streamed data traffic. When information (such as streamed music) is transported across the internet, it is divided into smaller pieces called packets that are automatically forwarded through various nodes and connection points when they are sent across networks (e.g., Sprenger 2015). This process is called packet switching and is arranged according to a protocol known as Transmission Control Protocol and Internet Protocol, or TCP/IP. Simply put,

TCP/IP governs how packets are structured (their size, what information they contain etc.), how they move (which paths they take across networks) and how they are assembled when they reach their destination (a necessity since information is split up into multiple packets that take different routes on its journey across networks). A packet sniffer is a computer program that intercepts incoming and outgoing packet transmissions when the internet is used. Thereby, it also decelerates streams and makes visible the plethora of packet transmissions that normally remain hidden below the surface and interfaces of computer screens.

In the context of computer programming, packet sniffers are frequently used for diagnosing network problems, detecting network intrusion attempts, gathering network statistics, and evaluating the effectiveness of security systems like firewalls or spam filters. In my research, however, I repurposed a packet sniffer to study what happens when content is streamed on Spotify. For this, I used a packet sniffer called Wireshark, which is a free, downloadable, and open-source program that is currently one of the world's most popular tools for monitoring network traffic. In detail, Wireshark was used to intercept the network traffic during two Spotify streaming sessions that lasted for 20 minutes each and were initiated in Stockholm, Sweden. During these sessions, a series of five songs were played on one Spotify free account and one Spotify premium account. All plays were activated manually and careful measures were taken to ensure that only Spotify's data traffic was monitored.

The collected data—which made up the key source material studied in the final article—provided a snapshot of what Spotify's data infrastructure looked like at a particular location and point in space and time. It also resulted in the capture of 13,271 different Spotify-related packets that made up about 12 megabytes of data in total. After the packets had been captured, they were analyzed manually in collaboration with Andreas Marklund and Roger Mähler at Humlab, Umeå University. Here, the origins and destinations of packets were explored by decoding the various IP-addresses that appeared in the intercepted data. The contents of packets were also analyzed in search of traces of third-party software use and hints of compression techniques that had facilitated the streaming of music during the experiment. In addition, the analysis involved looking for clues as to why and how the captured packets had succeeded (or failed) in being sent.

In this sense, the process of capturing data through packet sniffing was, again, followed by a strategy of studying packets in close-up, carefully untangling the

information kept within them. This involved adopting a methodological strategy of taking into account “small gestures and apparently insignificant actions” that occur in relation to technologies (Krajewski 2018, 354), such as evidence of geographically dispersed computers having greeted and made themselves known each other. Since many of the packets were encrypted, however, it is important to note that it was not possible to gain full insights about their content. Still, the information obtained was sufficient enough to map the locations of various data centers across the globe from which data had been pulled (and transferred to) during the experiment. There was also sufficient data to begin charting the patchwork of third-party software solutions, standardized protocols, and compression techniques that had enabled Spotify to stream music during that particular time. I say particular time since it is, necessary to stress that the use of packet sniffers is inevitably bound to the specific context when data is captured—much like when an API is used as a research tool. Despite this limitation, however, the experiment initiated further investigations into the various actors that had been activated when content was streamed and provided a rich starting point for exploring the organization of data infrastructures.

Media archaeology

A third academic field whose methods have been important in my work is media archaeology: a branch of research that seeks to understand our current media situation by ‘digging’ into the histories and materialities of media technologies. Media archaeology is a mode of thinking which involves seeing “media cultures as sedimented and layered” and a method through which past, present and future media realities can be excavated and explored (Parikka 2012, 3). Traditionally, media archeological research investigates how we arrived at our current media situation by exploring the “objects, apparatuses, and remnants of past media

cultures” (ibid., 64).³² Here, archaeology is understood as an intellectual and practical effort to excavate media apparatuses to study their constitution.

Methodologically, this is commonly done by rummaging through “textual, visual and auditory archives as well as collections of artifacts, emphasizing both the discursive and the material manifestations of culture” (Huhtamo and Parikka 2011, 3). At its core, media archeological research insists on the materiality of both analog and digital media and strives to get ‘close to machines’ by reaching into the material layers of technical devices. One key thinker in media archaeology is Wolfgang Ernst, who describes his media archaeology as “an archaeology of the technological conditions of the sayable and thinkable in culture, and excavation of evidence of how techniques direct human or nonhuman utterances” (Ernst 2012, 195).³³ For Ernst—much like Kittler and McLuhan—it is not the content of media that is most interesting, but rather the channels through which content moves. In broad strokes, media archaeology thus provides a framework for paying attention to the material and patchworked nature of communicative networks.

My research does not belong to the field of media history and does not set out to reflect on historical media developments and/or forgotten media technologies (as much media archaeological research does). However, it draws from the experimental approach to methods that is present in most media archeological research and has been inspired by the media archaeological focus on the materiality of technological innovations. In particular, I build on research that uses media archeological methods to study the internet, platforms, and software (Apperley and

³² Media archaeological research generally draws from research on modernity (Crary 1988; Friedberg 1993; Giedion 1948), new film history (Ceram 1965; Gunning 1990; Zielinski 1999), and explorations of the relativity of the “new” (Gitelman 2006; Huhtamo 1997; Marvin 1988; Zielinski 2006). The approach is also heavily influenced by Walter Benjamin’s “early excavations into the rubbles of modernity” (Parikka 2012, 5; Benjamin 2008), Marshall McLuhan’s emphasis on remediations and the mythologies that surround media ([1964] 1994), Michel Foucault’s writings on ‘archaeologies of knowledge’ (2002), and Friedrich Kittler’s extension of Foucault’s ideas, which involve grounding ‘archaeologies of knowledge’ in the study of media technologies (1990).

³³ Other key works in media archaeology include Siegfried Zielinski’s research on “the deep time of the media” (2006), and Erkki Huhtamo and Jussi Parikka’s writings on the field of media archaeology as such (Huhtamo and Parikka 2011; see also Parikka 2012).

Parikka 2015; Goddard 2015; Starosielski, Soderman, and Cheek 2013; Solomon 2013; Wardrip-Fruin 2011). In this research, media archaeology provides a form of gaze that directs attention towards “not only to the material substratum beneath or behind Internet ‘content’ such as its technical components ... but also the technical, economic, social and environmental relations that both sustain the Internet and are generated by it” (Goddard 2015, 1764). As Rory Solomon argues, software is particularly open for archaeological analysis due to its layered and “stacked” qualities (Solomon 2013). Given that computer programs are composed of multiple levels of code and layered data structures, they also lend themselves to archaeological excavations.

In my close reading of packets for example (article II), I ‘excavate’ the various layers of information that are encompassed in packets and thereby reflect on the global data transmissions that are triggered by the single decision to press ‘play’ in the online domain. This article develops Nicole Starosielski, Braxton Soderman, and Cris Cheek’s research on “network archaeology,” which pays attention to the materiality and histories of networks, as well as the “discrete connections that they articulate, and the circulatory forms of data, information, and socio-cultural resources that they enable” (2013). The authors ask what it means to “excavate a connection” and propose that media archaeological projects could be expanded to consider “data structures that facilitate networked movement” (ibid.). In picking up on this idea, article II (“Tracking Online Streams”) traces how streamed music travels through various globally distributed nodes and connection points, highlighting the material arrangement of data infrastructures.

In article I (“Close Reading Big Data”), I build on the works of Wolfgang Ernst, who encourages research concerning the communication and speech acts that occur between machines and consequently explores how technologies express themselves (2012). As Ernst describes it, media archaeology is “both a method and an aesthetics of practicing media criticism, and an awareness of moments when media themselves, not exclusively humans anymore, become active ‘archaeologists’ of knowledge” (2012, 55). Ernst encourages scholarship that pays attention to “modes of writing that are not human products but rather expressions of the machines themselves” and argues that the observation of such “subconscious qualities of technical media” lies at the heart of media archeological research (ibid., 58). This methodological strategy is applied in my study of the curious content that was

found in The Echo Nest's database concerning artists and composers. Here, I follow Ernst's call to use "the media archaeological ear" to listen to "the noise of the transmitting system itself" (Ernst, 2012, 68) and reflect on the whispers, hiccups, and peculiar association skills of The Echo Nest's web-crawlers.

Relatedly, article III ("The Editorial Playlist as Container Technology") can be described as an effort to trace the playlist's "archaeology of form"—that is, its role as a transport and storage device, means of communication, cultural formation, and technique of administration (Young 2013). As Liam Cole Young explains, tracing archaeologies of form involves excavating the functional histories and genealogies of formats, exploring how they process and transmit content across space and time (*ibid.*). Article III reflects on the form and function of playlists and their role in containing and keeping music in place—at the same time as they open music files to various forms of measurement, commodification, and calculation. In particular, I suggest that the playlist can be approached as a "container technology" (Sofia 2000) and locate playlists within a longer history of containment by technical means. Thereby, playlists are also re-inscribed into a long history of logistics management and commodity transportation.

To summarize, this dissertation uses a media archaeological lens to study the layered and interlocking nature of software technologies within online music distribution. By deploying media archaeological tactics of disassembling the stacked nature of communication systems (Solomon 2013), directing attention towards the material substratum operating beneath or around music content (Goddard 2015), and paying attention to the noise of transmission systems in order to gain insights about their workings (Ernst 2012), I illustrate how the digital technologies that sustain online music distribution are entangled in complex webs of economic, cultural, and technological relations that underpin and allow music to move and be heard.

Ethnographies of technology

A final methodological approach that this dissertation expands on is technologically and digitally-oriented ethnographic research. While I have not conducted any long-term fieldwork (in the sense of studying a specific cultural setting during an

extended period), ethnographic methods—and their ways of drawing together source materials and positioning the researcher vis-à-vis the object of study—have informed my strategies of collecting and analyzing empirical data. Apart from adopting a media archaeological optic and digital methods-approach to the study of digital technologies, this dissertation thus uses ethnographic sensibilities to explore the workings of software.

Traditionally, however, ethnographic research has placed people's experiences, thoughts and beliefs at the center of attention, rather than studying technologies in themselves (which this dissertation seeks to do). This is also true among the many ethnographers who have ventured into the digital sphere. Beginning in the early 2000's, a wide range of scholars in anthropology, sociology, and media studies began exploring the digital domain under the headline of what has been called "virtual ethnography" (Hine 2000; 2015), "netnography" (Kozinets 2010), "online ethnography" (Bengtsson 2014), and "digital ethnography" (Hjorth et al. 2017; Pink et al. 2016a). What most of these ethnographers have in common is an interest in studying issues concerning identity-making, cultural formations, and social media use—often with a focus on online community building (e.g. Boellstorff 2008; Coleman 2014; Horst, Hjorth, and Tacchi 2012; Manning and Gershon 2013; Nardi 2010; Postill and Pink 2012; Kelty 2008). In other words, digitally oriented ethnographic studies tend to privilege reflections on human life-worlds over technical considerations, and thus display an anthropocentric orientation in the study of digital media.

Recent publications on digitally-oriented ethnography have also made a point of taking "a non-digital-centric approach to the digital" (Pink et al. 2016b) in similar ways as media scholars have called for a "non-media-centric" approach to media studies (Couldry 2012; Morley 2009). This dissertation, however, seeks to go in the opposite direction. I want to take an ethnographically informed digital-centric approach to the digital. By this, I mean that I want to use digital ethnographic methods *and* place digital technologies as the object of my inquiries. In many ways, this approach implies a break with traditional digital ethnographers, who have sometimes explicitly argued for the need to treat "the digital not as an object of study, but as a methodological approach" (Boellstorff 2012). I show that it is possible—and desirable—to do both. Digital technologies can (and should) be approached as objects of research *and* as methodological tools.

In finding support for this approach, ethnographic research stemming from the field of science and technology studies has proven particularly helpful. For instance, the field of Actor-Network Theory (or ANT) provides a useful framework for approaching technologies as objects of study and co-active agents in the making of social worlds (Callon 1998; Latour 2005; Law 1992). In the book *The Making of Law*, for example, Bruno Latour traces how law is materialized and enacted through a range of objects and technologies such as files, documents, “stamps, elastic bands, paperclips, and other office paraphernalia” (Latour [2002] 2010, 71). Thereby, Latour highlights the importance of considering the agency of things in the study of culture. In similar ways, this dissertation takes software technologies seriously as agents that shape—and are shaped by—everyday life.³⁴

Here, I also draw from the work of Susan Leigh-Star, who already in the late 1990s called for studies that “attend ethnographically to the plugs, settings, sizes, and other profoundly mundane aspects of cyberspace” (Leigh-Star 1999, 379). Leigh-Star encourages scholars to concentrate on the wires, protocols, and computerized standards of network technologies—i.e., the ‘boring’ background infrastructures that may seem secondary to the ways cultural events play out online but are, in fact, crucial components in the unfolding of the world. Leigh-Star suggests that the ethnographic study of unexciting infrastructures can be achieved through a combination of “historical and literary analysis, traditional tools like interviews and observations, systems analysis, and usability studies” (ibid., 382). Technology, she suggests, can also be grasped by studying the physical properties of technical artifacts and exploring the traces of activities they leave behind. The latter is especially a methodological tactic that is pursued in this dissertation as I intercept the traces of activity that streamed content transmissions leave behind in article II, consider the material and technical properties of playlist artifacts in article III, and analyze traces of odd musical identifications produced by automatic content identification systems in article IV.

In terms of approaching digital technologies with the help of an ethnographic toolkit, I also build on anthropological and sociological “technographic” research,

³⁴ Other scholars in the field of science and technology studies have engaged in ethnographic studies of everything from Xerox photocopy machines (Suchman 2005), to software-aided clinical records for patients in medicine (Bruni 2005).

which involves combining descriptions and observations of technology in order to study its dynamics (e.g. Kien 2008; 2009; Vannini, Hodson, and Vannini 2009; Rammert and Schubert 2006; Bucher 2012; 2018). This approach has been described as an effort to pay attention “to the cultural dimensions of technology and to the technological dimensions of culture” by observing, contextualizing, comparing, and developing concepts to better frame and understand the interplay between technology and the social (Vannini, Hodson, and Vannini 2009, 464). It has also been described as a “descriptive-interpretative approach to the understanding of software, rooted in a critical reading of the mechanisms and operational logic of technology” (Bucher 2012, 71). On a practical level, attending to software technologies ethnographically implies “looking at the relations of which it is part, the contexts in which it is located, the practices that construct it socially, and the other objects that cross its trajectory” (Bruni 2005, 362). While my research does not rely on traditional ethnographic methods such as interviews or personally spending time in selected locations and field-sites, I have engaged in participant observations, especially in combination with digital methods.

With an emphasis on *participation* (not directly with humans, but with digital technologies and systems) my experimental digital methods have involved direct engagements with software and algorithms in ways that have triggered and prompted them to act. As Mike Michael, Matthew Fuller and Olga Goriunova describe it in the book *Inventive Methods*, these methods have not only sought to report on events but also act on them, and not only study happenings but also make things happen (Lury and Wakeford 2012, 9; see also Eriksson et al. 2019); an approach which shares the ethnographic imperative of engaging with the objects and subjects of study. In article II, for instance, I directly interacted with Spotify by initiating a series of plays on the platform to study the network traffic it triggered. Similarly, I directly engaged with The Echo Nest’s database when using its API, prompting a series of queries and retrieving information. In both of these cases, my direct engagements with software shared many similarities with ethnographers who participate in social gatherings. If traditional, ethnographic forms of participant observation can be conceptualized as a form of qualitative micro-observations of cultural events that speak to broader social tendencies (Clifford and Marcus 2008), my observations of software can be described as a form of micro-observations of technology that seek to reflect on wider social and cultural developments.

Taken together, this dissertation sits at the methodological crossroads between the digital humanities, media archaeology, and ethnographic inquiries into technology. I argue that the combination of these three methodological fields provides a particularly useful starting point for exploring the role of software in everyday life. As an academic point of departure, this methodological intersection is open to experimentations with digital methods, pays attention to the logics and modes of knowledge production that is held within machines, and encompasses qualitative and ethnographic sensibilities in the sense of not only studying software from afar, but also getting close to engage with it. Importantly, it is also a methodological starting point that highlights the need to take digital technologies seriously as both as objects of study *and* strategic research tools.

On materials and methodological limitations

While details concerning my strategies of collecting source materials can be found in each of the articles in this dissertation, a few broader remarks can be made with regards to my ways of gathering and analyzing data. To begin with, my strategies of collecting source materials regarding the operations of software have followed Taina Bucher's (2012; 2018) call to study software through its underlying technological constitution (as manifested in protocols, whitepapers, patent applications, technical specifications, and software/product descriptions), its visible outputs (as displayed through interfaces, internet archives, databases, and APIs), and its descriptions by users, journalists and corporations (in news reports, interviews, blogs, discussion forums, industry reports, policy documents, business reports, press releases, and marketing events etc.). In short, one could thereby say that I have followed the extensive traces, reports, and documents that are left behind by—or created in the vicinity of—software systems involved in digital music distribution. In line with Bucher, I view this wide variety of documents as points where the software technologies studied are revealed and expressed. In other words, I see software technologies as entities that are not solely confined to the algorithms or pieces of code that constitute them, but also exist and are manifested in a multiplicity of textual, visual, audio, audiovisual documents (Bucher 2012).

When collecting data for my case studies, I have not followed a rigid set of rules or protocols concerning what should be perceived as source materials and instead remained open to the broad variety of traces that are left behind digital technologies. Given that the focus of my research has been digital technologies and digital distribution, my source materials have all been collected online. For example, I have searched for materials using search engines, patent databases, academic journal archives, online discussion forums, and wikis. As URL addresses tend to dissolve quickly, I have stored copies of all my online source materials in a pdf or jpg format and saved them in a research database. Often, the discovery of one type of source material has produced a snowballing effect, as links or references have pointed to other important sources. In particular, I have looked for source materials that say something about how the software technology in focus is utilized, has been developed, and operationalize particular ideas and norms. By collecting a wide range of materials, the aim has also been to map and assemble a type of ‘biographical knowledge’ (Appadurai 1986; Kopytoff 1986) or ‘thick description’ (Geertz 1973) of the software solution in question, with interest in both its history and workings.

As previously mentioned, I have also sometimes interacted with software, thereby engaging in a form of participant observation that has triggered software to ‘speak’ and act (Latour 2005, 79; Bucher 2012; 2018). Here, the main source materials have consisted of a series of blog posts (that were gathered through The Echo Nest’s API) and packets (that were obtained using a packet sniffer). In both cases, I gathered the data using quantitative methods (the data capture of network traffic in article II, and the retrieval of music metadata through an API in article I). However, I chose to analyze this data through qualitative readings (hence, the title of article I is also “Close Reading Big Data”). As I explain in both of these articles, my efforts to approach ‘big data’ through a qualitative lens has been informed by a desire to counter the aggregated way by which large datasets are commonly read. By zooming in on ‘big data’ instead of quantifying it, I have sought to conduct alternative readings of its content and qualities, paying attention to details, intricacies, and particularities rather than its meaning at scale.

With regard to methodological limitations, however, it is important to state that my research is not as technologically detailed as some scholarship in software studies. As with all research, there has been a limit to my ways of ‘digging deep’ into technological processes. For example, you will not find page-long close-readings of

code in this dissertation (e.g., Cox and McLean 2013; Berry 2008). I have strived to get as close to digital technologies as possible within the boundaries of my knowledge and abilities. Yet the fact that I do not have a background in computer science (or proficient programming skills) has, of course, shaped the nature of my research. There are different opinions, and even disputes, regarding the extent to which scholars who use digital methods and/or study software should also be trained in computer science (e.g., Gold 2012). I am convinced that we need as many critical reflections on software as possible and that it would therefore be a shame to only leave such research to those with double degrees.³⁵ I am also convinced that is possible to conduct rigid research that uses and scrutinizes digital tools if one collaborates with those who have a background in the computational sciences (as I have done at Humlab). When working on my own—and approaching documents such as complex patent applications or technically detailed white-papers—however, it has not always been easy to grasp all technical details. To fully understand my source materials, I have continuously consulted everything from online programming tutorials to Wikipedia pages, and friends, colleagues, and acquaintances.

When writing about software, I have worked hard to describe and interpret their functions in ways that can be understandable to the wider public. Again, this has sometimes been challenging, but it has also resulted in descriptions of software that I hope are clear and understandable, also for those who are not technical experts. While there could be reasons to problematize scholars taking on the role as ‘translators’ of the workings of software (as with all acts of translation, this involves putting oneself in a significant power position), I have felt that it has been important

³⁵ Here, it is also interesting to draw parallels to ethnographic work, where the potentials and risks of entering a field site as a cultural ‘stranger’ have been a recurring topic of debate (e.g., Clifford and Marcus 2008). While being culturally immersed in a field site or culture clearly has benefits for those who study it, it might also be the case that an outsider perspective can analyze cultural dynamics with new eyes. For instance, an outsider might be able to notice naturalized patterns of behavior and ask ‘stupid’ questions that reveal taken for granted truths and belief systems. While the analytical perspective of the outsider does certainly not guarantee that *better* knowledge about culture is produced, it may have the potential to shed a *different* light on cultural dynamics in ways that may enrich understanding. In similar ways, there may be benefits of entering the domain of code and software as someone who is not already fully immersed in the field and shaped by the beliefs, norms, and values that are forwarded by institutionalized technical education, for example.

to depict the workings of software using a language and conceptual framework that is not overly technical. These efforts have implied that I maintain a certain technical distance to the software systems studied in my articles, yet they have still allowed me to engage with technology in ways that are sensitive to its political *doings* and strategies of evaluating, ranking, and arranging the world.

Finally, there is a need to address a central limitation regarding the placement of software as an object of study, as I have done in this dissertation. This limitation concerns the rapid pace at which technologies develop, transform, and go out of date. The rapid ‘updateability’ of digital media is a central and well-known problem for anyone studying digital processes—and this has of course also affected my work in this dissertation. I initiated my research in late 2014, and in the roughly five years that have passed since then, much has changed in the digital domain. Unlike a historian who studies archival materials that lie relatively untouched in bookshelves or storage depositories, many of the software technologies explored in this dissertation are updated, tweaked, and transformed on a daily—if not hourly—basis through recursive feedback loops and continuous software development and maintenance.

A recent transformation in the area of network protocols aptly illustrates this methodological difficulty. On September 26, 2019, Google, Mozilla, and Cloudflare (one of the world’s largest Content Delivery Networks) started utilizing HTTP/3—the latest iteration of the HTTP protocol which governs online traffic (Cimpanu 2019). This means that from September 26 and onwards, all users of Google Chrome or Firefox who visit a Cloudflare-hosted website will use the new protocol. With time, it is expected that HTTP/3 will replace HTTP/2—the HTTP protocol that is currently most commonly used across the internet. What is important about this change is that HTTP/3 no longer builds on TCP/IP but a protocol called UDP/IP (or User Datagram Protocol/Internet Protocol). UDP/IP still organizes online traffic as packet transmissions, yet it introduces fundamental changes to the structure of online communication (Rodriguez 2018). For instance, HTTP/3 utilizes fewer handshakes between client and server, deals with packet loss differently, and encrypts information in new ways, thus (allegedly) allowing for faster and more flexible content transmissions (*ibid.*). Hence, my experiment with packet sniffers could generate radically different results today—not just because experiments of this kind are always bound to time and place, but also because the

internet could be on its way to undergo a groundbreaking shift in terms of how online communication is organized and controlled.

Against the background of the example discussed above, some might argue that trying to grasp what is currently going on in the digital sphere is a painstakingly hopeless effort. I would argue that there is an absolute need to investigate the digital present, even if it is in constant motion. There are two primary motivations behind this stance: first, I believe that digital technologies are simply too influential and important to be left aside by critical research—even if such research runs the risk of having a short expiration date. Second, I believe that even faulty speculations about the technological present will have importance in the future—not least for historians who seek to map how those living in the midst of the digital transformation tried to make sense of it. We need more histories of—and critical reflections on—influential software technologies in everyday life and those can only be written if enough studies document the present. If anything, then, I hope that this dissertation will serve as a historical record of the possible interpretations that could be drawn from our current technological situation.³⁶

³⁶ Lev Manovich makes a similar argument when he argues for the necessity to engage in the production of “theories of the present” in his classic book *The Language of New Media* (2001, 32–34).

4. About the articles

As stated, this dissertation builds on four articles that each explore different software solutions and algorithmic systems that are involved in managing the logistics of digital music. In this chapter, I provide a summary of each of my publications and explain how I found my way to these particular case-studies. I also relate my publications to the work done within the research project *Streaming Cultural Heritage*, within which this dissertation has been written.

Article summaries

Article I (“Close Reading Big Data”) was published in the journal *First Monday* in July 2016 and builds on research that was initiated in spring 2015. The article traces how digital music distribution is increasingly powered by algorithmic mechanisms that collect, sort, and value large amounts of web-based data. In particular, the article explores how the Spotify-owned company The Echo Nest captures and analyzes online information about artists to produce music recommendations. The Echo Nest describes itself as a “music intelligence platform” that “synthesizes billions of data points and transforms it into musical understanding.”³⁷ In doing so, it

³⁷ See The Echo Nest’s webpage, <http://the.echonest.com/> (accessed October 1, 2019).

is also a company that is involved in transforming public online information into commercial music metadata by gathering and analyzing a wide range of information from the web (tweets, blog posts, music reviews, news articles, artist biographies, etc.). My article maps how such data capturing mechanisms take place and especially highlights the curious and peculiar logics that The Echo Nest's algorithmic web crawlers introduce to digital music distribution.

In particular, the article analyzes one specific category of data that was found in The Echo Nest's database: blog posts. This is a content type that The Echo Nest uses in its efforts to capture tastes, opinions, and sentiments from the web. For instance, The Echo Nest uses blogs to produce ratings of how 'hot' or 'popular' artists are by conducting semantic analysis on textual content. Such ratings are then fed into music recommendation systems on platforms like Spotify and thereby regulate how music and musicians are valued and promoted on a global scale. My analysis of The Echo Nest's collection of online information revealed the arbitrary and odd logics according to which large-scale online content analysis sometimes takes place. When conducting a close-reading of 1386 blog posts that were obtained through The Echo Nest's API (blog posts that The Echo Nest had defined as containing relevant information about musicians), it turned out that only 22 percent of the blogs provided wholesome information about the artist it was meant to describe. Meanwhile, 68 percent of the analyzed blogs only briefly mentioned the correct artist, and instead focused on other artists or topics (such as or spaceships or crossword puzzles). The remaining 10 percent of the analyzed blog posts were either duplicates, dead links, or blogs that contained virtually no information about the musician it was meant to describe.

In the article, I discuss how The Echo Nest's 'big data' analysis thus privileges quantity over quality in the evaluation of music and artistry and also brings with it language biases. For instance, 89 percent of the analyzed blog posts were written in English even though 15 of the 22 artists that were studied in the experiment were non-English natives. I also highlight the difficulties of training automatic systems for online information retrieval and reflect on the unruliness and wildness of algorithms and source materials that do not always behave as planned (such as when links die, or content is duplicated over and over again). In short, I found that The Echo Nest's web-crawlers had created an archive of obscure, frivolous, and sometimes outright bizarre musical blog posts. Ultimately, the article shows how a

close reading of big data forces us to consider the random margin that is inherent to digital technologies—a random margin which problematizes the notion that technologies are under our control.

If article I problematizes the logics of large-scale algorithmic analytics engines, article II (“Unpacking Online Streams”) instead takes a closer look at the material and networked infrastructures that make such forms of data analysis possible in the first place. This research was conducted during late 2017 and early 2018, and the final article was published in the journal *APRJA* in late 2018. By exploring the kinds of data transmissions that a single ‘click’ on Spotify can trigger, this article sheds light on the visible and invisible layers of data traffic that permeate streamed music distribution. In particular, the article presents a methodological argument regarding the potential of using packets (i.e., the small units of data into which online communication is generally split) as a starting point for investigating infrastructural data arrangements. By monitoring the packet transmissions that were activated during an ordinary Spotify session, the article explores how so-called ‘packet sniffing’ can provide insights into the turbulent and complex data arrangements that underlie digital music distribution.

In particular, the study highlights how packet sniffing can open up for considerations on the interruptions and redundancies that mark online circulations of digital music. While streaming is often presented as a smooth and frictionless means of transmitting sound, erroneous packets transmissions and other types of digital breakdowns continuously underlie digital music distribution. In the article, I show how packet sniffing makes it possible to study such ruptures in close-up. Furthermore, the article highlights how investigations of packets provide a basis for mapping the multiplicity of third-party actors and infrastructures that facilitate streamed content transmissions. By backtracking and studying the remains of machine operations that are visible in packets, the article explores the complex material routes through which streamed music is shipped. This, for example, involves tracing how music content is transported through globally distributed data centers, cable systems, cloud platforms, and content delivery networks. It also includes tracing the codecs, compression techniques, and natural resources that are needed for streamed music to happen. In this sense, the article’s key contribution is to show how packet sniffing can assist in showing alternative images of network transmissions; images that challenge metaphors of smooth and immaterial streams.

Article III (“The Playlist as Container Technology”) leaves discussions around data centers, fiber optic cable systems, and digital energy use behind and instead explores a common format for music delivery: the playlist. Materials for this text were primarily gathered during 2018, and the article (which is currently under peer review) was first submitted to the *Journal of Cultural Economy* in March 2019. Playlists have been part of online music distribution since the dawn of the world wide web and constitute a simple technical solution for assembling and arranging digital music. In this article, I explore the role and function of the playlist format in organizing music and markets. In particular, I suggest that the playlist can be approached as a container technology—i.e., a technical solution that serves to store, preserve, and transport music objects and thereby uphold logistical operations within the music industry. Such an approach seeks to complement previous research concerning playlists, which has often analyzed the emotional and affective dimensions of playlists from the perspective of users, but failed to account for how playlists forward calculative, mathematical and logistical retail flows within the digital music economy.

On the one hand, the article considers how the playlist format—much like other container technologies—materialize principles of commodification, modularization, and automation in ways that enhance the control and oversight of (music) commodities. On the other hand, the article also discusses how the playlist format is far from a perfected means of measurement and control, and sometimes acts as an ‘evil’ and unruly transport device that causes unsettlement. By drawing from a series of controversies around playlists—disputes concerning ‘fake’ plays and ‘fake’ content—the article highlights how the capacity of playlists to ‘safely contain’ sound has recently been questioned. Moreover, the article reveals the order—and disorder—that playlists introduce into digital music distribution. Here, I show how a container approach to digital technologies can help us consider how digital technologies simultaneously embody rationalism/calculability (in the sense of materializing and promoting calculative logics) and uncertainty/commotion (in the sense of handling content in unexpected and uncanny ways).

The fourth, and final, article that make up this dissertation (“In Pursuit of Musical Identifications”) builds on material that was collected between 2015 and 2019 and was submitted to the journal *The Information Society* in October 2019. In this article, I return to a discussion about a particular set of software solutions that have

importance for how music moves and is treated online. The article focuses on automatic content analysis tools and their administrative and bureaucratic role in identifying online sounds and governing digital music distribution. In particular, it outlines the history politics of YouTube's Content ID system; an audio fingerprint technology that is used to safeguard copyrights on YouTube. Content ID is built to make computers analyze and classify copyright protected sound and in the article, I suggest that the technology can be perceived as forwarding the '*informatization*' of music (van der Ploeg 2007); that is, the practice of making music machine readable through calculative, statistical, and algorithmic means.

In particular, I discuss how Content ID introduces content-based methods for indexing and analyzing sound; a method that turns the binary substances of sound recordings into searchable entities. This has given copyright owners access to fundamentally new methods for consulting online archives and enabled new strategies for identifying and regulating how music moves and is monetized in the online domain. Much like human fingerprint technologies (Cole 2001), I show how Content ID is engaged in distinguishing between legal/illegal forms of behavior and solidifies uncertain (material) identities by providing an opportunity to algorithmically 'read' and 'look inside' online content. In doing so, I also argue that Content ID (and audio fingerprint technologies in general) must be understood as a technology that amplifies human auditory knowledge in the online domain. However, I also discuss how Content ID's musical analysis frequently fails to acknowledge the ambiguities and complexities that surround cultural content, and highlight some of the controversies, errors, and democratic debates that have surrounded it. Ultimately, the article suggests that Content ID can be conceived as hidden identification tool that contributes to the automatization of cultural judgments and forces us to reflect on the cultural power that is allocated to software systems in everyday life.

Why these case-studies?

My choice to explore these particular case-studies has been guided by the idea that algorithmic recommendation systems (studied in article I), the globally dispersed technical nature of streamed content transmissions (studied in article II), the

intricate dynamics of digital music packages (studied in article III), and the effects of automatic content analysis systems (studied in article IV), constitute essential elements in online music distribution. Each of these case studies also point towards areas where central struggles and negotiations regarding music technologies currently take place. Article I highlight tensions around what happens when the task of determining and evaluating the relevance, quality, and value of music is transferred to algorithmic systems. Article II points towards the difficulty of grasping the width, politics, and environmental effects of global interconnectedness. Article III casts light on the commodification of music and how digital ways of assembling recorded sounds are subjected to manipulations and trickery. Article IV discusses the effects of wide-ranging online content surveillance; a phenomenon whose effects on the freedom of cultural expression online stretch far beyond the music industries. In different ways, my case studies thus point towards essential areas of debate regarding online music distribution; the politics of algorithmic evaluations of artistry, the hidden and sometimes troubling nature of streamed content transmissions, the murky business strategies behind commercial playlists, and the politics of online copyright policing.

Importantly, my choice to focus on these particular cases studies have also developed alongside the work that I have conducted within the research project *Streaming Cultural Heritage: Following Files in Digital Music Distribution*—a project that has studied emerging streaming cultures in general—and Spotify as a music aggregation service in particular. A key mission within this project has been to ‘follow music files’ as they are transported across digital networks, examining the different paths along which music travels and is made sense of in the online domain. Drawing from social anthropology and its interest in tracing the “cultural biographies” and “social life” of things (Appadurai 1986; Kopytoff 1986), the project has explored how music files are treated and valued within an increasingly algorithmically governed digital market for music (Eriksson et al. 2019). It has also studied issues around transparency in digital culture by combining interviews, participant observations and the analysis of Spotify’s ‘front end,’ with experimental investigations of the company’s ‘back end.’

When writing this dissertation, I have sometimes directly borrowed from methods developed within the Streaming Cultural Heritage project. In other cases, our collaborative research has guided my choice of topics or served as a background

against which I have later expanded on ideas. For instance, it was when I conducted background research regarding Spotify that I first came across The Echo Nest, whose undertakings became the focus of my first article. The Echo Nest's analysis of music is a key ingredient in Spotify's ways of promoting and recommending music, and as I learned about the company's involvement in classifying and valuing artistry and songs, I became curious to find out more about how its 'musical intelligence' was being produced. What would a snapshot of the type of data The Echo Nest collects from the internet look like? From where does it pull its materials in the first place? And what could this tell us about the logic and politics of algorithmic knowledge production?

The Echo Nest is certainly not the only company that conducts large-scale data analysis to power music recommendation engines. Yet given its connection to Spotify—currently the world's largest streaming platform which is solely dedicated to music—it is a business whose outputs have significant importance for how music moves online. Four years after the original article was published, The Echo Nest is still described as a key component in Spotify's global success (Constine 2018) which highlights the continued relevance of scrutinizing the company's undertakings.

Article II ("Unpacking Online Streams") was also borne out of work conducted within the Streaming Cultural Heritage project. In particular, it drew inspiration from one of the project's experimental interventions, where packet sniffers were used to study the arrangement of ad-tech systems on the Spotify platform (Mähler and Vonderau 2017; see also Eriksson et al. 2019). The original project experiment was aimed at mapping the actors that participate in so-called programmatic advertising—an algorithm-driven method for placing ads on digital platforms. In my article, however, I wanted to expand on this methodological starting point and discuss how the study of packets can also be deployed to map broader infrastructural arrangements around streamed music. Not limited to the study of ad-tech arrangements, my final article came to reflect on how packet analysis may function as a starting point for wider inquiries into the politics of (data) infrastructural arrangements. The article was developed during the 2018 Transmediale Festival in Berlin, and a related version of the text has been published in the book *Spotify Teardown* (Eriksson et al. 2019).

My interest in audio fingerprint technologies—the focus of the fourth article in this dissertation—had already been awoken when I did my first work on The Echo Nest,

which offers an audio fingerprint solution called Echoprint as part of its ‘music intelligence’ suite. The Echo Nest’s audio fingerprinting tool is an open-source solution and one of the numerous audio fingerprint solutions that currently exist. In the article “In Pursuit of Musical Identifications,” however, my focus is not on The Echo Nest’s audio fingerprinting tool, but rather YouTube’s (or Google’s) Content ID, which is arguably the most influential audio fingerprint solution in the world. As previously stated, Content ID’s evaluations of sound have a direct impact on how video content reaches roughly 1.9 billion monthly YouTube users (Google 2018)—a circumstance which, in and of itself, is a sufficient reason to investigate its ways of identifying, classifying, and performing sensitive boundary work regarding copyright protected content in the online domain.

The final article in this dissertation (“The Editorial Playlist as Container Technology”) also grew out of work that I had conducted together with Anna Johansson as part of the Streaming Cultural Heritage project. In the article “Keep Smiling!: Time, Functionality and Intimacy in Spotify’s Featured Playlists” (Eriksson and Johansson 2017), we explored how Spotify recommended playlists to users; playlists that are designed to cater to the presumed desires, needs, and wishes of music fans. In particular, we investigated how Spotify’s pre-designed playlists prescribe normative temporalities, neoliberal subjectivities, and functional approaches to music and sought to discuss how playlists carry ideas and assumptions about ‘the good life’. In article III, I wanted to take a step back and consider the broader function and role of the playlist format as such, focusing less on the specific content of playlists (or how playlists are named or dressed in images and descriptive texts) and more on their role in facilitating the transportation and delivery of music. The decision to approach the playlist as a container technology both grew out of my empirical data (playlists are frequently described as a type of programmed ‘containers’) and a desire to reflect on their role in arranging economic transactions, musical transportations, and the administration of advertising revenues.

While many other software solutions, formats, methods, and topics could have been the focus of this dissertation, I believe that these particular case-studies highlight critical components of the music industry in the digital age: its entanglements with algorithmic recommendation systems, global network infrastructures, dynamic and programmable content packages, and wide-ranging systems of content surveillance. If we want to understand the role of technology in governing how music moves in the online domain, it is thereby my firm belief that this is a good place to start.

5. Concluding remarks

This dissertation set out to study the role of software and algorithms in online music distribution in order to problematize the broader influence of digital technologies in everyday life. The aim of my research has been to bring forward a set of software technologies that operate in the background of the online economy and thereby also open them to scrutiny and critique. In response to my initial research questions, my investigations have traced four different techniques by which software regulate how music moves online: through web-crawling and the capture/analysis of written online statements about music (article I), through protocols and standards that govern the distribution of streamed music content (article II), through the packaging and containment of music in editorial playlists (article III), and through the informatization of music (article IV).

In each of these articles, I have also highlighted how the technical systems studied forward specific cultural logics: a logic where cultural value is equated with quantified online presences (article I), a logic where music is routed and shipped across controversial content delivery networks (article II), a logic where music is assembled in ways that enhance calculative, mathematical, and commercial treatments of culture (article III), and a logic where measurements of musical authenticity and originality is transferred to machines (article IV). Taken together, these studies show how software is trusted with the ability to perform sensitive and ongoing cultural boundary work in the online domain, whether it regards ways of valuing artistry, regulating how music is transported through geopolitically sensitive digital

networks, enabling the commodification of online behavioral patterns, or catering to the desires and demands of copyright owners.

These cultural logics are not unique to the online music industries, but rather relate to broader concerns about the role digital technologies in everyday life. The positive and negative implications of digitization are an ongoing source of public debate, and my research speaks to several key disputes that currently surround the digital domain. What, for instance, are the broader cultural and political implications of the metrification of everyday life and the tendency for digital technologies to reduce social interactions to clicks, mentions, and other types of quantifiable statistics and measurements? Which creative actors (musicians, artists) benefit from such metrified systems and who are left behind? To which extent should the wider public accept and/or endorse the often hidden and obscure means by which traces of online behaviors are captured, analyzed, and commodified? What constitutes a reasonable demand for transparency and accountability vis-à-vis platform owners in the digital domain? And how should the openness and freedom of public expressions on the internet be balanced with the financial interests of rights-owners, corporate actors, and those hosting online platforms?

The intent of my research has not been to deliver straightforward answers to these questions. Instead, my research has highlighted the complexity and ongoing tensions that surround increasingly influential software technologies. It goes without saying that digital technologies have introduced fundamentally new ways of arranging cultural consumption, yet the frameworks that regulate what such arrangements should look like are not yet settled. I have explored how these struggles and transformations are expressed in one cultural domain: the sphere of music, which is an area that lies at the heart of culture and politics. As I have shown, the judgements made by software technologies in online music distribution affect the everyday life of both musicians and audiences: it helps shape what artists are classified as ‘popular’ or ‘hot’ (and which ones aren’t), it assists in deciding through which routes streamed music travels (a process that involves engaging with contested actors such as content delivery networks), it packages and wraps music in such a ways that heavily commodifies the listening habits of audiences (and often does so in obscure and hidden ways), and it helps make vast amounts of online content intelligible, identifiable and governable (and thereby also sustains the power hierarchies that are embedded in the current copyright regime).

In what follows, I summarize what I believe are three of my main contributions to the field of media and communication studies. These contributions both speak to methodological issues and theoretical reflections on the role of software in everyday life. They also point towards areas where I believe we need more research in order to better grasp what digital technologies are doing in the world and how such actions affect us. In short, my dissertation contributes to future media research by highlighting the relevance of 1) digital and experimental methods, 2) a logistical conceptualization of software, and 3) research that accounts for the unpredictable in software.

On digital and experimental methods

At its core, this dissertation has demonstrated the continued relevance of media research that critically explores the role of software in everyday life. To study digital media is to explore a technical (infra)structure that establishes the preconditions that make communication and consumption possible in the digital sphere (Kittler 1990); it involves paying attention to the “underbelly of modern media—that is, the extensive, patch-worked, and varied electrical infrastructures that undergrid world processes of mediation” (Parks 2015, 364). Regardless of what audiences, musicians, or industry stakeholders might think of them, software technologies (such as the ones highlighted in this dissertation) exist and *do things in the world*; they continuously sort, evaluate, classify, arrange, transport, and govern the movement of cultural content online. Furthermore, they frequently do so in ways that are hidden and occur in the background of the online economy.

After having worked with this dissertation for five years—and simultaneously conducting an in-depth study of Spotify together with four colleagues (Eriksson et al. 2019)—it is my firm conviction that research in the field of media and communication studies need to complement hermeneutical approaches to digital technologies (interviews, focus-group studies, studies of people’s thoughts and beliefs regarding online tools etc.) with studies that explore new methods for understanding the material and technical dimensions of algorithms and software. As Jörgen Skågeby and Lina Rahm recently pointed out, contemporary “research runs a risk of relying too much on ‘superficial’ accounts of participation, inter-

activity and identity” if it does not have “the ambition to reveal the increasingly ubiquitous and obscured material operations of media technologies (and the power asymmetries literally built into them)” (Skågeby and Rahm 2018, 8). While the study of people’s beliefs, uses, and experiences of digital media might be relevant, this dissertation has demonstrated the benefit of bracketing traditional (and analog) research practices to instead scrutinize the technical constitutions and effects of software. “Power is realized in the *outcomes* of algorithmic processes”, as David Beer puts it (2017, 7, my emphasis) and for this reason, I have focused on exploring how software operates and works. Since software technologies are increasingly regulating our everyday life, they simply cannot be understood by media research that disregards the power and politics that is built into technology.

However, software technologies are also complicated objects of analysis. This is partly because of their rapid transformability and partly because of the fact that their technical specificities are often black-boxed and kept secret. From certain points of view, these forms of technical secrecy make perfect sense. If algorithmic systems (such as search engines or music recommendation systems) were fully open and transparent, they would be an easy prey for scammers and swindlers. Frequently, algorithmic systems are also the main asset for online services, whose chief competitive advantage might be algorithmic search engines or recommendation systems. A certain amount of concealment is thus expected—and sometimes warranted—with regards to algorithmic systems. Yet, given the significant influence of digital technologies in everyday life—and given the excessive opaqueness that continues to mark digital technologies—I argue that there is a need for humanistic research that utilizes experimental methods to ask critical questions about their workings and power. If such methods are not pursued, we run the risk of only having an understanding of digital technologies that is based on corporate self-descriptions. We also risk ending up in a situation where digital technologies remain to be viewed as a sole concern for the hard sciences, where fields such as computer science and engineering have traditionally ‘owned’ issues pertaining to software (Fuller 2008, 2). It is my hope that this dissertation—and its ways of illustrating the cultural and political dimensions of software—has shown that this would be a significant loss. As Eugene Thacker puts it, “the technical specs matter, ontologically and politically” (Thacker 2004, xii). Digital technologies are fundamentally cultural and must therefore be considered a central concern for the humanities.

In order to study digital technologies, I have suggested that scholars should explore creative and experimental methodological techniques that borrow ethnographic and media archeological tactics, but also tests and adopts digital tools. My ways of applying such methods have strived to go underneath the immediate interfaces of online technologies (i.e., the visual elements on websites or applications) and instead focused on the data capturing mechanisms, protocols, programmed packages, and content filters that govern online music distribution. In so doing, I have shown the benefit of paying attention to the material substrates of the online domain, as opposed to analyzing its tangible interfaces.

My methodological starting point has also highlighted the need to *turn digital methods towards digital technologies themselves*, placing algorithms and software as objects of study *and* taking advantage of their capacities as research tools. This has involved “engaging software in such a way that it can be used to operationalize its own critique” (Weltevrede 2016, 181). As previously discussed, this approach has often been lacking in media studies, digital humanities research, and the field of digital ethnography. By showing how digital methods can fruitfully be combined with a critical examination of software, my research thus answers calls for a more critically engaged digital humanities research (Berry and Fagerjord 2017) and accentuates the benefits of using creative strategies to circumvent the black-boxing of digital technologies. By testing, intercepting, querying, and experimenting with software (through APIs and packet sniffers) I have sought to directly engage with software as method, using it both to gather source materials and to challenge the workings of technologies themselves.

As our research team within the Streaming Cultural Heritage project experienced, however, the use of digital methods can also be highly controversial.³⁸ Many of the legal frameworks that surround digital technologies are currently opaque and therefore make the task of collecting and analyzing online data difficult. While some legal regulations—such as the EU directive on the legal protection of computer programs—leave a gap for experimental tinkering and critical examinations of software and code (EU Directive 2009/24/EC), we learnt that global tech

³⁸ As a result of the digital methods used within the project, we received a cease and desist letter from Spotify, who also made an attempt to cut the project’s funding (Wang 2019; Andy 2017). More about this in the book *Spotify Teardown* (Eriksson et al. 2019)

companies may not hesitate to pressure and take action against scholars who exercise such rights (Eriksson et al. 2019). This raises serious questions about tech companies' efforts to stifle the freedom of academic research at a time when their power and influence over society is increasing.

The example of Terms of Service agreements (ToS) is particularly illustrative of the grey zones that currently surround the use of digital methods. ToS agreements are corporate contracts that users (and journalists/researchers) have to sign before registering an account on most online platforms (think of the endlessly long agreements that precede signing up on pretty much any online service). Many ToS agreements give platform owners exclusive and extensive rights to record user behaviors and sell such data to third-party actors (Eriksson et al. 2019). At the same, however, they are frequently also formulated in ways that effectively prohibit critical research. As of February 7, 2019, for instance, Spotify's ToS agreement states that its users are forbidden from "copying, redistributing, reproducing, 'ripping', recording, transferring, performing or displaying to the public, broadcasting, or making available to the public any part of the Spotify Service" (Spotify 2019). Given that scholarly research is public in nature and premised on the ability to gather, copy, and archive source materials, this means that researchers who follow such agreements to the point, would have severe difficulties with critically scrutinizing the technical and social events that occur on platforms. Consequently, contemporary researchers that study the online domain constantly have to grapple with whether or not they should violate ToS agreements and to which extent this could be regarded as justifiable.

In the articles that constitute this dissertation, I may have violated ToS agreements,³⁹ which highlights the need to stress the necessity of safeguarding the autonomy of critical scholarship that uses digital methods to collect data. Such research may, for example, engage in the emerging scholarly field of algorithmic auditing, which scrutinizes potential instances of algorithmic discrimination online (Edelman, Luca, and Svirsky 2017; Eslami et al. 2017; Sandvig et al. 2016). In line

³⁹ In article I, I was given permission to use The Echo Nest's API for research purposes. My experiments in article II, however, involved signing in and using a Spotify account (and thereby involved signing a ToS agreement). It should be stressed, however, that using a packet sniffer to monitor one's own network traffic is perfectly legal.

with this field of research, my studies have uncovered some of the algorithmic power asymmetries that are embedded in software. It is my firm belief that we need more research that explores—and questions—how music recommendation engines may marginalize non-English performing artists (article I), how streaming services organize their business in ways that challenge principles of net neutrality (article II), and how automatic content analysis tools enable wide-ranging surveillance in ways that benefit a small number of music industry stakeholders—yet have significant implications for the freedom of speech online (article IV).

Ultimately, the issue of using digital methods *without* the endorsement of tech companies—and possibly in violation of ToS agreements—boils down to a matter of balancing the public interest in gaining insights about algorithmic systems while still respecting corporate interests. In a situation where some scholars see the internet and social media becoming militarized (Zittrain 2017), and reports of murky online data transactions are released more or less nonstop (e.g., Ward 2018), I believe that there is an absolute need to protect the scholarly (and journalistic) right to use experimental methods that are not directly sanctioned by the tech industry—and sometimes go against corporate interests. In the end, I hope that this dissertation has shown the benefits of adopting an open, experimental, collaborative, and flexible research design when asking critical questions about the logics, norms, and power that is embedded in digital technologies.

On a logistical conceptualization of software

A second scholarly contribution of this dissertation—both for humanistic research on digital media and forthcoming media studies research—is to highlight the relevance of a logistical conceptualization of software. Matthew Fuller recently noted that there is a growing amount of research about software from the perspective of the humanities, yet “we are still at a point where a critical language to understand the wider domain of computational culture is only beginning to ferment” (Fuller 2017). I have suggested that a logistical framework can productively be used to pinpoint the role of software in everyday life. Logistical operations facilitate connections between people and things and involve “the art

and science of managing the mobility of people and things to achieve economic, communication and transport efficiencies” (Neilson 2012, 322).

By approaching software technologies through a logistical lens, I have illustrated how logistical operations do not just concern transportations of analog goods such as foodstuff, consumer electronics, or raw materials, but also take place in the online domain. Traditionally, scholars of logistics have tended to focus on areas that are associated with the ‘hard’ and heavy industries, such as factories, warehouses, and shipping ports (Rossiter 2016; Cowen 2014; Chua et al. 2018). Yet, I have suggested that a logistical framework can also productively be transported into the ‘soft’ and cultural domain. In doing so, I have shown how logistics is not just a matter of large-scale cargo shipments but also the planned management and movement of digital materials. Hence, I argue that logistical considerations need to consider not only the shipment of analog stuff (the planned circulation of commodities and materials such as iron, oil, cars, and chocolate bars) but also digital content (the organized shipment of online photographs, email messages, and not least music).

Furthermore, I have shown that a logistical approach is especially useful for distinguishing and specifying the *bureaucratic*, *administrative*, and *organizing* functions of software in the context of online music distribution. Such an approach, I argue, is not least vital and necessary in relation to the growing focus on the infrastructural dynamics of digital technologies. In recent years, an increasing body of scholarly work has adopted an infrastructural framework of analysis in the study of networked communication (e.g., Hu 2015; Parks and Starosielski 2015), studying the infrastructural dynamics of topics such as platforms (Plantin et al. 2018), cloud storage techniques (Hu 2015), and internet governance (DeNardis 2012). In the words of Brian Larkin, infrastructures can be understood as the material and “built networks that facilitate the flow of goods, people, or ideas and allow for their exchange over space” (Larkin 2013, 328). Larkin also describes infrastructures as “matter that enables the movement of other matter” and “objects that create the grounds on which other objects operate” (ibid., 329) and thereby frames infrastructures as material configurations that support and facilitate markets and social interaction.

Clearly, media infrastructural research lies close to logistical investigations, yet I would argue that a logistical conceptual framework provides well-needed specificity

when the role and function of software technologies are discussed. By highlighting and discussing logistical operations rather than infrastructural ones, the focus is moved one step up in the layer of material structures that organize online flows of online goods and information. If infrastructures constitute “the matter that enables the movement of other matter” (Larkin 2013, 328), then a logistical framework reminds us that things do not move across infrastructures by themselves. In order for infrastructures to be utilized, there is a need for logistical planning, monitoring, and oversight. As Ned Rossiter aptly puts it, “infrastructure makes worlds. Logistics govern them” (Rossiter 2016, 4–5). Logistics is about steering, orchestrating, accelerating, slowing down, and/or monitoring flows of information and when the distributive role of software technologies are discussed, a logistical framework is thus useful for pinpointing precisely these types of administrative and bureaucratic tasks.

What emerges when software technologies are approached through a logistical lens is an understanding of software as entities that orient subjects, objects, and technologies in time and space (Durham Peters 2013). A logistical framework also highlights that at a very basic and taxonomic level, media are entities that “record, transmit, or organize; they govern time, space or power” (Durham Peters 2009 n.p.). By overseeing, regulating, directing, and keeping track of musical flows, software technologies perform managerial and custodian tasks in the online domain: for one, they grant and deny access.⁴⁰ My case studies have shown how algorithms and software logistically *connect* people (artists, fans) and things (data, recorded sounds) by creating musical ‘intelligence’ and recommendations (article I), *coordinate* how music moves between personal computers and global data centers/networked architectures during streaming sessions (article II), *arrange* interaction between users and advertisers in the case of playlists (article III), and

⁴⁰ For an extended discussion on the custodian tasks of software, see for example Tarleton Gillespie’s recent work on the custodian tasks of online content moderators (Gillespie 2018), or Markus Krajewski’s writings on servants and servers (2018; also Canales and Krajewski 2012). Krajewski traces how the role of serving has moved into the digital domain and increasingly become a task performed by machines and computers. In so doing, he shows how digital technologies now have a unique ability to allow, and disallow flows of goods and information, in similar ways as doorkeepers, butlers, and other (human) assistants have occupied roles as informational gatekeepers in the past. And as Krajewski notes, “our dependence on today’s [technological] servants could not be any greater. All power belongs to the indirect, networked agents, and interstitial things” (ibid., 355).

provide rightsholders with an opportunity to *administrate* control over vast amounts of creative video content (article IV). To borrow from Liam Cole Young, I have thus shown software is “deployed in order *to order*” (2014, 15). While the term logistics may seem stiff and culturally barren (*ibid.*), it has been my aspiration in this dissertation to display how logistical operations are, in fact, deeply cultural processes that facilitate intimate connections between people and things.

On the unpredictable in software

Finally, this dissertation has pointed towards the necessity of considering the unpredictable outputs of software. Digital technologies promise an “error-free world of 100 percent efficiency, accuracy, and predictability” and are frequently portrayed as the embodiment of logic, reason, and rationality (Nunes 2011b, 3). Yet, as my research has shown, unpredictabilities and surprises constantly emerge around software. My articles have discussed the odd and peculiar association skills of web-crawlers (article I), the flawed and incomprehensible machinic speech acts that occur between machines (article II), the uncanny existence of playlist fakes and manipulations (article III), and algorithmic misjudgments of sound (article II). Moving forward, these instances of unpredictability teach us something important about the volatile nature of software governance. While we may work hard to control and domesticate algorithms and digital technologies, fully controllable software is an untenable ideal. Contrary to the perception that computational technologies produce predictable, controllable, and well-ordered outputs, my work has shown how software is often messy, surprising, chaotic, and disorganized.

On the one hand, I have suggested that instances when digital media go ‘awry’ can function as a useful entry point for gaining insights about the workings of software. As Olga Goriunova and Alexei Shulgin once put it, a technical error or glitch offers a “possibility to glance at software’s inner structure” (2008). Instead of considering algorithmic misjudgments as problems that need to be fixed, I have suggested that they can be used as productive analytical entry points in the study of technical systems. If we want to understand the role of technology in everyday life, we should not only reflect on their anticipated technical outputs—such as occurrences where technologies succeed in targeting audiences or making content flow seamlessly

between computers—but also pay attention to their ruptures, failures, and peculiarities. This is akin to what Foucault describes as a genealogical method that follows “the complex course of descent” into passing events and seeks “to identify the accidents, the minute deviations—or conversely, the complete reversals—the errors, the false appraisals, and the faulty calculations that gave birth to those things that continue to exist and have value for us” (Foucault 1977, 146).

Relatedly, I have also suggested that accounts of the unpredictability or ‘evil’ of media (Fuller and Goffey 2012) is needed since it counters the seductive view that communication technologies are sophisticated and controllable. A focus on digital oddities, mischiefs, and disturbances provides a framework for problematizing notions of technological progress. Instead of disregarding failures, I therefore argue that they should be brought into the light. As algorithmic systems now have substantial influence over financial systems (MacKenzie 2018), automate drone strikes during warfare (Schuppli 2014), help determine who receives an organ transplantation (Roscoe 2015), and calculate the price of life necessities like water (Ballesteros 2015), the relevance of accounting for the unpredictability and manipulability of software is urgent.

In this dissertation, I have shown how the unpredictabilities of software may lead to artists being evaluated ranked based on someone else’s work (article I), or cultural content being illicitly monetized or blocked from view on one of the world’s largest and most influential websites (article IV). These outputs point towards the broader need to take the potential for surprises, mishaps, or accidents into account when technologies are given the power to act in the world. As Federica Frabetti puts it:

Every choice we make with regard to technology always implies an assumption of responsibility for the unforeseeable. Technology will never be calculable—and yet decisions must be made. The only way to make politically informed decisions about technology is not to obscure such uncalculability (Frabetti 2015, xxvii).

In other words, one must always ask what the consequences could be if a particular software solution does not behave as planned. In bringing algorithmic misjudgments to the fore, I am not primarily calling for the development of sharper systems that eliminate mistakes and technical blunders, since such a standpoint indirectly suggests that there could actually exist such a thing as flawless tech-

nologies.⁴¹ The point I want to make is not that the unforeseen outputs of software are problems in themselves. On the contrary, technological fallacies are, as Frabetti points out, in many ways a prerequisite for the development of software and a necessary evil that has many positive side-effects for creativity.⁴² Instead, the problem with technological unpredictabilities occurs when such unpredictabilities have potentially disrupting effects for society at large. In other words, the issue lies not in the faulty decisions made by software technologies themselves, but in the *effects* such unpredictabilities might have as a result of the power that has been assigned to them. It is not unpredictable software solutions that are the problem, but the broader tendency to delegate responsibilities to technologies in such a way that their unforeseen outputs may discriminate or cause harm.

As I discussed in article I, such problematic effects may, for instance, occur when a music recommendation system that (partly) bases its recommendations on calculations of how often artists are mentioned online, cannot differentiate between the band Queen and writings about queens in general (queen-sized beds, the Queen of Great Britain etc.). This may, for example, result in a disproportionate tendency to recommend artists and musicians that have generic names, at the expense of the promotion of others. In the case of semantic text analysis, it may also lead to peculiar associations between musicians and bedroom furniture and/or royal families. Here, it is of course important to recognize that The Echo Nest may have adjusted its system to account for such confusions over names (of this, however, we know very little). Yet, the forms of algorithmic mishaps that the Queen-example illustrates calls for continued interrogations into the skewed evaluation mechanisms and computational confusions that software technologies entail.

As discussed in article IV, problems surrounding the unpredictability of software may also occur when content filtering systems identify recordings of musical works that belong to the public domain as instances of copyright abuse (Rhodes 2018; Bottum 2018), or classify political satire as copyright violations, even though their use of music is within legal boundaries (Liberalviewer 2015). As many others,

⁴¹ However, it would admittedly be nice if Content ID was accurate enough to leave cat videos alone on YouTube (Ernesto 2015).

⁴² In making this argument, Frabetti draws on Derrida's notion of *pharmakon*, which captures how "technology entails both poison and remedy, danger and opportunity" (Frabetti 2010, 128; Derrida 1981).

including civil rights organizations (LibertiesEU 2017), scholars at the Max Planck Institute (Hilty and Moscon 2017b; 2017a), and tech moguls (Cerf et al. 2018) have argued, the wide-ranging adoption of algorithmic content filters run the risk of seriously stifling the freedom of expressions online. Automated copyright filters balance on a thin line between fairly supporting cultural creators and enforcing a democratically damaging system of online censorship and public surveillance.

As the European Union recently approved a new copyright legislation that is likely to intensify the adoption of automatic content filtering online, concerns have also been raised regarding how this legislative update will reinforce already existing power imbalances in the online domain (e.g., Senftleben 2017; Collins 2018). In detail, the updated EU Copyright Directive that was approved by the European Council in April 2019 abolishes the current safe-harbor non-liability regime, meaning that online service providers (websites, online platforms) will soon be held financially and legally responsible for all content that is uploaded by their users (Collins 2019). This change heavily pushes online service providers towards scrutinizing all user-generated content *prior* to its publication; a task that is often insurmountable to complete manually and is thus expected to lead to a spike in the use of algorithmic content recognition tools.

Currently, Google's Content ID system is considered to be state of the art in the context of automatic content recognition and as more platforms are expected to license copyright filters as a result of the updated EU copyright law (in order to preempt and avoid legal sanctions stemming from copyright violations), it has been pointed out that power over the movement and visibility of online content could become even more concentrated in the hands of a small number of already monopolistic tech companies who control—or have the financial means to develop—advanced content recognition tools (Senftleben 2017; Collins 2018). Currently, Google's ownership of Content ID already means that the company has acquired an extensive ability to track, monitor and identify a significant portion of the world's musical (and audiovisual) cultural heritage (Heuguet 2019). Important issues with regards to software systems such as Content ID does thus not only concern their potential for causing accidents and algorithmic misjudgments, but also their ways of centralizing power in the hands of those who own and control them.

To wrap up, our understanding of the economic, political, and cultural effects of digital technologies is very much an unfinished and ongoing project, and this dissertation has explored only a small corner of the technical sphere that governs online music distribution and the movement of cultural content online. It is my hope, however, that my work has continued the tradition of opening up digital technologies for critical social research and helped shed light on some of the intersections between software, culture, and power. I also hope that the conceptual materials developed in this dissertation will assist in the future development of frameworks that forward a critical, deeper, and more nuanced understanding of the role of software in everyday life.

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