

# 1 RFID and the Infrastructural Imagination

The world has become more and more mobile. More people travel across national borders. Products travel farther and more frequently in the global economy. Roads handle an increasing number of drivers. Mobility infrastructure is used more heavily than ever before. At the same time, people have also become more interested in data of all types and tracking mobility in new ways. We live in what has been called an “information society” that seeks to record everything it can.<sup>1</sup>

Lying at the convergence of these two trends—an increase of mobility and a growing focus on datafication—is a mobile technology relatively few people know about: radio-frequency identification (RFID). RFID is simultaneously a communicative mobile technology and an important part of various infrastructures. RFID systems include a tag that carries data, a reader that accesses that data, and middleware that transmits the data from the reader to a larger system. RFID tags can be as small as a grain of rice and can be sewn into clothing or embedded in packaging. They are found in credit cards, passports, key fobs, car windshields, subway cards, consumer electronics, the walls of tunnels, and even inside animal and human bodies.

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So what is RFID? I explain the technical side in more detail in chapter 3, but for now think of RFID as a suite of technologies that uses radio waves to communicate identifying information. Many tags feature an Electronic Product Code (EPC)<sup>2</sup> that helps uniquely identify billions of tags in circulation. Other tags, such as those found in public transportation “smart” cards and contactless credit cards, transmit serial numbers that grant access to database information.<sup>3</sup> In other cases, RFID tags paired with sensor technology transmit environmental information, such as the temperature of food products or the wear on infrastructure.<sup>4</sup>

Many people reading this book are likely within reach of an RFID tag. There might be an antenna in their contactless credit card or a chip in their pet. If they checked this book out from the library, an RFID tag might be on the inside cover of the binding. Or readers may have used their smartphone to pay for something using a mobile payment application, which uses a modified form of RFID called near-field communication (NFC). But unless people look closely or start thinking about the implications of infrastructure, most of these tags will remain out of view, even as RFID technology has the potential to invisibly communicate data about the identity and movement of people and objects. One of the main goals of this book is to pull back the curtain on RFID, examining where to find the technology, the social impact of RFID as mobile identification infrastructure, and how RFID is one small technology that nonetheless showcases the larger push toward the Internet of Things and big data.

The question remains why anyone should read a book devoted to RFID, especially a book that looks at RFID from a sociological perspective. I believe that answer lies in what other scholars have identified as somewhat of a blind spot in some media studies research: not enough research has focused beneath the

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level of the interface.<sup>5</sup> Researchers tend to pay attention to the technologies they can see, the technologies with which people interact every day. More words than could possibly be discussed here have been written about the primary media technologies people use to communicate, ranging from the written word to new smartphone applications. People tend to ignore what happens in the background of their interactions with the physical world. That lack of attention is designed into the system. As sociologist Susan Leigh Star has argued, and countless articles have repeated, infrastructures are “by definition invisible” and they only “become visible upon breakdown.”<sup>6</sup>

People notice infrastructure mostly when it stops working, not when it works as planned. Take mobile phone infrastructure as an example. Most people do not pay attention to cell phone towers, and engineers go to great lengths to hide towers by disguising them as buildings and trees.<sup>7</sup> Many people think about cell towers only when their coverage fails and they find themselves wandering around trying to pick up a signal. At its core, infrastructure is that which people rely on but rarely think critically about.<sup>8</sup>

What happens when infrastructure is ignored, however, is that researchers end up focusing only on the level of the interface. They emphasize the human intentionality behind people’s communicative practices without acknowledging how much communication now occurs beneath the level of human perception.<sup>9</sup> Additionally, when people ignore established infrastructures, the infrastructures’ histories are erased, and they become more invisible and seemingly magical than they really are. After all, as I explore in this book, infrastructures are not quite as invisible as many people think. Rather, infrastructures can be extremely visible and invisible in alternating patterns. An infrastructure

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can initially be met with widespread hype and marketed as transformative, making the technology anything but invisible. Once adopted and put in place, however, that hype fades, and the “cutting-edge” technology fades into the background. As anthropologist Brian Larkin put it, “Invisibility is certainly one aspect of infrastructure, but it is only one and at the extreme edge of a range of visibilities that move from unseen to grand spectacles and everything in between.”<sup>10</sup>

RFID is a technology that exemplifies the range of visibilities Larkin discussed. On the one hand, the technology often fades into the background, and many people interact regularly with RFID technologies without knowing at all what they are. On the other hand, RFID has been a massively hyped and feared technology: the original concept of the “Internet of Things” focused on RFID, RFID has been identified as possibly the most important identification technology since the barcode, NFC (a type of RFID) was positioned as a technology that would alter how people interact with the built environment, and RFID has been met with widespread fears about surveillance in some communities. Some groups of evangelical Christians have even identified the technology as a possible harbinger of the end times. Consequently, it is not quite accurate to say that RFID is an “invisible” infrastructural technology. Throughout most of this book, I look at how RFID is embedded in objects and designed to be not noticed, but I also take into account the moments wherein RFID becomes hyper-visible, whether through the marketing of new capabilities or the fears about what the technology can tell larger entities about how objects exist in the world.

The hype and fears almost all center on the main technological capability of RFID: the ability to collect unique identification data about almost any material object. Consequently, much of

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this book focuses on what I call *object communication*, which I define as *the ability of objects that have either no or little computing power to wirelessly communicate identifying data with infrastructure*. Object communication is less complex than the more complicated types of machine-to-machine communication people are working on in the realms of artificial intelligence, but examples such as the ability of a pair of jeans with an RFID tag to communicate identification data wirelessly, a subway card to link contactlessly with a terminal, or a car windshield to be read while traveling full speed down a highway show how objects that have no internal computing power play an important communicative role in the functioning of physical spaces. In addition, each example involves a sorting of some type. After all, as I explain throughout the following chapters, many of the types of object communication I examine feed into larger infrastructures of identification. Through tags of various shapes and sizes, billions upon billions of objects and bodies can be differentiated from one another and feed into a large-scale technological scheme of classification and identification.

My argument in this book is that—with the growth of communicative objects—we need to pay more attention to infrastructure, but not just in the traditional understanding of media infrastructure as that which supports interpersonal communication. We need to think of infrastructure as *that which communicates*. We also need to understand the role various infrastructures play in uniquely identifying and sorting objects in the physical world. Consequently, I position RFID as an infrastructure of identification that works simultaneously as an infrastructure of communication. I show that the physical world is already communicative, and much of what it has to say involves telling the built environment exactly what this “thing” is that is moving

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through the world at a given point at a given time. I embark on that exploration of infrastructures of identification by using the technology of RFID as a jumping-off point to examine the links between mobile technology and infrastructure, focusing on one specific technology as a way to explore the changing landscape of object communication.<sup>11</sup>

Ultimately, this book is about RFID as mobile technology, but at the same time it is not just about technology. The chapters that follow feature explanations of RFID systems, but the goal is to do more than just write about a single type of technology. Rather, I use RFID to examine larger issues such as the Internet of Things, big data, and privacy and surveillance. Looking at tags and microchips may seem like a strange way to get at some of the biggest buzzwords in contemporary society, but limiting my focus to RFID provides concreteness to what often are vague discussions about societal trends. The focus also enables the chapters to develop the core argument of this book: *RFID is a communicative mobile technology that can uniquely identify and sort billions of objects and turn various physical processes into trackable data.* Everything from the pedigree of the prescription drug I fill to the identities of my rescue dogs can be communicated through RFID technology.

The chapters that follow tell stories of RFID technology, but they do so without falling back on dry, technical descriptions. Instead, I follow RFID from pilgrimages in India to the Book of Revelation. I look at how RFID can surveil handwashing in hospitals and shift the visibility of supply chains. I mention projects that use RFID to communicate wine vintages and groups that believe RFID is part of a vast governmental conspiracy. Most importantly, I use these examples to show how the ubiquity of RFID can give voice to objects in novel ways and provide the

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identification necessary for a communicative, differentiated environment of networked things. Before moving on to those examples, however, the rest of this chapter explains why RFID is important; I also situate my examination of the technology within existing research. I conclude the chapter by outlining the structure of the book and providing a roadmap that will take us on a journey from the tools in Australian hospitals to the restaurants at Disney World.

### RFID as Mobile Media

Back in May 2014, I was giving a conference talk about the location-based mobile application Foursquare that enabled people to share their location with friends. The talk went well, and the audience seemed interested in what my panel had to say about the social practices of location sharing. In the Q&A, however, Rich Ling—one of the major figures in the field of mobile communication studies—asked a provocative question: Why do mobile media scholars study less-popular locative technologies rather than technologies like RFID? The point he was making is a simple one to anyone aware of both popular press and academic discussions of mobile locative media. Researchers and journalists tend to focus on the snazzy new smartphone app people use to find their location or look up information about their surroundings. The tech press, for example, wrote extensively on the “check-in wars” between applications like Foursquare and Gowalla,<sup>12</sup> though neither application passed fifty million users, and Gowalla had failed by 2012. Academic mobile media literature is filled with accounts of location-based gaming,<sup>13</sup> location-based social networking,<sup>14</sup> mobile mapping,<sup>15</sup> and location-based search.<sup>16</sup>

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Not coincidentally, the forms of locative media covered extensively in the press and in sociological research focus mostly on location-based applications people use to learn about their surroundings. That focus makes sense. The buzz surrounding a cool new locative application is likely higher than with something like RFID tags that track people and things. A new mobile app is flashier than a supply-chain technology or a card reader in a train station. And I do not point out the abundance of locative media research as a criticism. Much of the research is excellent and important. My first two books examine smartphone technology,<sup>17</sup> so I understand why people pay more attention to location-based mobile games that never approached a million users than they do to RFID technology that has been deployed in the billions. Media scholars are accustomed to focusing on user practices, and mobile applications—at the level in which someone interacts with an interface—are where those user practices are typically found.

But returning to Rich Ling's question, the fact remains that relatively ignored technologies like RFID tags are used more frequently to track information about people and things than are mobile applications. Many of the locative applications or locative artworks that have been extensively researched never surpass a few million users, and that is the high end in many cases. RFID tags, on the other hand, have been deployed in the tens of billions. One RFID company—Impinj—has put more than ten billion tags into circulation and expects to have over one hundred billion tags in circulation by 2020.<sup>18</sup> And that is only one company. The actual number of RFID tags deployed is impossible to calculate definitively, but the forecasting firm IDTechEx estimates that, in 2017, 8.7 billion RFID labels were used just in retail, another 825 million tags were used in transportation, and

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480 million tags were used to meet animal tagging regulations.<sup>19</sup> In total, the RFID industry is worth more than \$11 billion USD and will almost certainly continue to grow.

Of course, popularity does not equal importance. Billions of staples have been used in the last hundred years as a mobile technology, but no one is writing a book about staples (though I would probably read it). Additionally, the fact that not much sociological research exists on RFID does not automatically mean there *should* be research on the topic. So why look specifically at RFID? Mainly because RFID forms crucial infrastructures of identification that shape our world in diverse ways, enabling everything from certain types of physical movement to new retail practices powered through data. The technology moves with objects and bodies and links them with the built environment, most often in a process that involves individuating one object from others of its type. Consequently, RFID can show how increasingly distinct identification practices rely on material infrastructure to govern how bodies and objects move through networks of transportation and supply.

Much has been written in science and technology studies (STS) research about how classification systems work to differentiate people and things, make them identifiable, and place them in categories. Sociologists Geoffrey C. Bowker and Susan Leigh Star, for example, have written extensively about how infrastructures of classification work to “sort things out,” whether those infrastructures involve disease definitions or racial sorting.<sup>20</sup> Less has been written, however, on the types of sorting enabled by mobile technologies like barcodes and RFID. As explored throughout these chapters, the increased data capacity of RFID can sort billions of objects from one another. These infrastructures of identification have significant implications for the

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communicative networks that shape our physical spaces, the relationships between bodies and institutions, and the increasingly detailed forms of identification necessary for the Internet of Things. While RFID is only one example of a technology used to semi-automate the process of “sorting things out,” it is a crucial example whose story remains untold and should be an important piece of the mobile media landscape.

In addition, an argument that underlies the examples in this book is that RFID is representative of a larger trend toward more and more granular practices of identification. In chapter 2, I look at how the move from barcodes to RFID is a move toward enhanced specificity. That move is part of the larger trend—a trend that includes everything from biometric scanners to enhanced driver’s licenses to improved analytic techniques for analyzing web traffic—of practices enabled through hardware and software that sort and differentiate one body or one thing from all the others. Consequently, while the focus of this book remains on RFID, the shifts in specificity of data collection are also likely just as relevant to various mass collections of data that shape our lives. This book is about separating and segmenting the individual (defined broadly) from the mass. That segmentation may involve differentiating one cow from all the others or one student in a classroom from her classmates. Regardless, the practices rely on the tiny tags and the data they produce to provide new types of visibility about movement and identification in the physical world.

The uses of RFID for producing the types of data discussed above are diverse. The data on tags may relate to someone’s mobility in the case of toll tags or subway cards; they may relate to supply-chain logistics or the inventory on store shelves; or they may relate to the state of any object communicating with

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another object in the Internet of Things. But in all these cases, attaching or embedding RFID tags in objects turns the objects into animated, communicative, and uniquely identifiable pieces of the physical environment. Often the tags themselves do not even have an internal power source, so they can cost as little as ten cents a tag and work in near perpetuity because they have no battery to be replaced. The tags can then make literally tens of billions of objects uniquely traceable. They help enact a form of mobile communication that can do anything from open a toll-gate to log an item's location in a blockchain. By no means should scholars abandon the focus on interpersonal mobile communication, but I hope my examination of RFID will join other infrastructural research in expanding analyses of mobile media to look beneath the level of direct engagement with mobile interfaces.

Additionally, while this book is about RFID technology, it is not *about* RFID in the traditional sense of just describing the current state of a technology. Instead, as I hope to make clear in proceeding chapters, RFID is interesting not just because of its technological features but because it works as a window through which to explore larger societal issues. The examples I describe show how one small, often ignored, technology works in the background to control, standardize, and enable data projects, the Internet of Things, and corporeal mobility. I build on the work of Bowker, Star, and others to explore the increasingly complex practices used to sort, differentiate, and classify objects and bodies in the physical world. More than just expanding on processes of "sorting things out," however, I use RFID as a way to show the increasingly crucial role communicative technologies play in processes of identification, aiding and building on the various classification systems that already exist. Additionally, one of the key contributions of this book is to show how RFID

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represents a shift in the increasingly fine-grained processes of sorting and differentiation. Identification of various types has only become a more important piece of the “technological unconscious” that shapes our world, and RFID is a specific site at which to track that shift.

Consequently, readers coming to this book for a how-to guide for RFID deployment or a full account of the contemporary RFID landscape will likely be disappointed. I focus on the technology, but this book is not just about technology. If this book is successful, then the points I make, the issues I explore, will be relevant to people interested in infrastructures of identification and people interested in more traditional mobile communication. The topics I discuss in the forthcoming chapters will build on other works that have examined how a variety of sociotechnical assemblages, ranging from algorithms to databases to physical infrastructure, have reshaped what it means to communicate in the contemporary world.

### **Contextualizing RFID**

A broad claim that RFID is an understudied technology is a bit of an overstatement. Technical and business-oriented fields feature hundreds of articles about RFID use. Computer science journals have published many articles about using RFID to interconnect networked devices.<sup>21</sup> Engineering journals have included articles about using RFID and sensors to monitor networked urban infrastructure.<sup>22</sup> Marketing journals have featured articles about using near-field communication to connect with customers.<sup>23</sup> Logistics publications have included articles and books about using RFID to track products and manage inventory.<sup>24</sup> The RFID industry

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also has the *RFID Journal*, which is a trade publication focused on RFID-related issues.

RFID has received less attention, on the other hand, from the social sciences and humanities. A few important discussions of “software-sorted geographies,”<sup>25</sup> “code/spaces,”<sup>26</sup> and smart city surveillance<sup>27</sup> mention RFID, but only as one small part of a more broadly defined socio-technical assemblage. Three significant exceptions to the lack of research from social scientific and humanistic perspectives were articles by Nigel Thrift,<sup>28</sup> Katherine Hayles,<sup>29</sup> and Martin Dodge and Rob Kitchin<sup>30</sup> in the mid-2000s. Thrift identified RFID as a key piece of the “technological unconscious” that operates in the background of people’s everyday interactions with their surrounding spaces. He wrote that “the fourth innovation, and perhaps in the end the one likely to prove the most powerful, is the RFID (Radio Frequency Identification) tag.”<sup>31</sup> Yet despite more than two hundred citations to his article, few scholars took up his provocation to analyze and theorize the impacts of RFID technology. One exception was media scholar Katherine Hayles, who argued that the central theoretical concerns about the technology “are the effects of RFID in creating an animate environment with agential and communicative powers.”<sup>32</sup> She also provoked researchers to develop a framework that bridges human agency and RFID without collapsing distinctions between the two. Such a framework would allow us to “shed the misconception that humans alone are capable of cognition.”<sup>33</sup> Finally, geographers Martin Dodge and Rob Kitchin also wrote explicitly about RFID, using the technology as an example of how the “application and automatic processing of digital identification codes are key to the evolving forms of contemporary governmentality and capitalism.”<sup>34</sup>

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I return to these articles throughout this book, but for now I want to point out that—despite these thinkers’ status as prominent figures in the study of technology and society—few have stepped forward to address their provocations. The researchers cited above identified RFID as a potentially transformative technology that could reshape processes of identification and the composition of physical spaces, but few articles have taken RFID on its own terms and analyzed its impact on space and place, agency, or surveillance. The technology has remained in the background of larger discussions of infrastructure, urban studies, and global flows of products and people. This book shifts the foreground/background relationship by moving RFID to the forefront of discussions of mobile technology. Or, in Bowker and Star’s terms, part of the goal of this book is to perform an “infrastructural inversion” that focuses explicitly on infrastructure.<sup>35</sup> Throughout these chapters, I examine how RFID as infrastructure of identification can alter relationships between bodies and institutions, between objects and databases, and among communicative material “things” that become networked in new ways. After all, with the hype surrounding the Internet of Things, it will become increasingly important to engage with the effects of the hardware and software that make it possible to connect and identify objects. That engagement is even more important because, as I examine next, much of the language people use to discuss the internet erases the physical infrastructures that make new communication practices possible.

### **Determinism and the Internet of Things**

When people talk about the internet, they often slip into imagining the internet as a space somehow separate from the physical world. Theories of the internet often imagined a “cyberspace”

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separate from physical space. The same is true for other digital technologies. For instance, mobile phone researchers talked about forms of “absent presence” in which people engage with the digital spaces of the phone call and ignore their physical surroundings.<sup>36</sup> By no means is the tendency to separate the digital and physical confined to academic arguments. The popular press loves articles about how smartphones distract people or how internet use stops people from engaging with people or places nearby. Even popular metaphors like “The Cloud” suggest a separation between the physical and digital by implying the digital is some kind of ethereal substance that does not rely on tangible, material infrastructure.

Despite the tendency to dichotomize the physical and the digital, the digital is of course always physical. Digital information is not stored on a cloud somewhere; it is not “virtual” as opposed to “real.” But with the growth of the Internet of Things, the idea that the digital and the physical could ever be separated has become even more tenuous, if not outright impossible, to maintain. The Internet of Things refers to objects that can connect with each other and with the internet. In other words, everyday objects become networked and shape the way data about the physical world is produced and collected. The term has become a marketing buzzword, with sources predicting that tens of billions of objects will be connected to the internet and to each other.<sup>37</sup> But through all the hype, the concept gets at a core, straightforward idea: objects will increasingly form networked connections and have new voices with which to speak and share data.

As I explore in more detail in chapter 4, according to some sources, objects in the Internet of Things must have their own internet connection. However, the original concept of the Internet of Things was introduced in a 1999 presentation about RFID

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technology,<sup>38</sup> and if tens of billions of objects are connected in the Internet of Things, many of those objects will be too small and too cheap to have their own internet connection. An RFID tag can make objects machine-readable, uniquely identifiable, and communicative. The tag can enroll anything from a pair of pants to a child walking through Disney World into a communicative infrastructural network. Possibly most important, typical RFID tags have the storage capacity to assign a unique identifying number to hundreds of billions of objects. Consequently, the identification and communication affordances of RFID are why the technology, in all the different forms I explore in these chapters, is a key piece of the growing Internet of Things.

Merely pointing out that RFID is a part of the Internet of Things misses a larger point about the agential effects of the technology. In her article about RFID, Katherine Hayles’s provocation was that researchers needed to build a bridge between human agency and the agency of RFID. Doing so would necessitate avoiding the two poles that often dominate discussions of technologies: technological determinism and cultural determinism. On the one hand, RFID does not come from nowhere and then fully determine behavior in any technologically deterministic sense. The fact that radio waves exist and have agency does not mean it was inevitable that schools in Brazil would find a way to track students with RFID tags. On the other hand, RFID does have agential effects that allow certain behaviors and disallow others. The technology makes certain ways of acting and certain processes of identification possible. Without the technology, certain behaviors and forms of identification data just would not exist.

Consequently, conceptualizing the agency of RFID requires theories that avoid the tendency toward determinism. In the

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space between cultural and technological determinism, social theories have arisen that recognize the agency of technology. Theoretical movements such as object-oriented ontology,<sup>39</sup> activity theory,<sup>40</sup> phenomenology,<sup>41</sup> assemblage theory,<sup>42</sup> vital materialism,<sup>43</sup> and actor-network theory<sup>44</sup> all complicate questions of agency, distributing the ability to act and influence among networks of humans and things. These theoretical foundations all have major differences, but what they share might be more important: a recognition that things do have agency and are worth studying on their own terms.

These theories of nonhuman agency shape the examples I analyze in this book and how I talk about RFID's role as an infrastructure of identification. The foundation of my approach, an approach that argues that RFID technology is an active agent in the datafication of the world, is based on the work of people like Bruno Latour,<sup>45</sup> Jane Bennett,<sup>46</sup> John Law<sup>47</sup> and many others who argue for distributed approaches to understanding action. I view RFID as an actant, defined as "that which has efficacy, can do things, has sufficient coherence to make a difference, produce effects, alter the course of events."<sup>48</sup> As I show throughout this book, RFID has the potential to alter the course of events and contribute to new forms of data collection and new types of object communication. I am not arguing that RFID causes larger societal movements like big data or the Internet of Things, but I also do not believe RFID merely responds to the push toward massive increases in volumes of data. Instead, RFID's role is both shaped by existing trends and helps shape those trends. The technology acts in concert (or not in concert, in some cases) with diverse and widespread networks of both humans and things.

Recognition of technological agency does not mean that this book is just about a technology. The stories I tell feature humans

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and animals, not just radio waves and antennae. My arguments are informed by the people I interviewed, the lab directors I followed, and the trade shows I attended. Human actors play a role in this book, as they should when discussing technology. After all, RFID does not come from outside society. But humans are not always front and center throughout this book because I am equally interested in exploring the agency of the technology. In effect, drawing on actor-network theory, I do not view technology and society as separate.<sup>49</sup> The actions of humans and things work together to hold what people think of as society together. The recognition of a flatter ontology of agency shows the value of tracing RFID tags through the environment. After all, as political scientist Jane Bennett writes, there is “public value in following the scent of a nonhuman, thingly power, the material agency of natural bodies and technological artifacts.”<sup>50</sup>

### **Objects and Their Stories**

A major part of the Internet of Things, especially in relation to RFID, involves tracking mobility. RFID tags, after all, can be thought of as a form of locative media.<sup>51</sup> Despite the warnings of some conspiracy theorists I discuss later, the tags do not use locative functions such as GPS or Wi-Fi triangulation, but they do transmit identification data about where an object is at a given time because they transmit to fixed readers. Consequently, the system often knows where the reader is, so it knows where the tag is. As one example, an RFID-enabled school-attendance system shows where and when a student enters a classroom because their RFID device wirelessly connects with a specifically located reader. Consequently, RFID is an important infrastructural technology in what has been called the “mobilities turn,”<sup>52</sup> which is a movement in the social sciences and humanities that focuses

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on the importance of mobility in shaping contemporary life. As Mimi Sheller argued, one of the keys to mobilities research is the ability to analyze the effects of “infrastructures of mobility in creating the effects of both movement and stasis.”<sup>53</sup>

The mobilities turn was based partially on the work of geographers such as Doreen Massey, who argued that place cannot be understood without understanding flows of people, objects, and information.<sup>54</sup> Following Massey and other thinkers, sociologists Mimi Sheller and John Urry argued that “travel has been for the social sciences seen as a black box, a neutral set of technologies and processes.”<sup>55</sup> One of the goals of mobilities research is to open up that black box to better understand how objects, people, and information flow in the globally networked world.

As both a mobile technology and a piece of communicative identification infrastructure, RFID can create logs of objects’ mobility. The technology can, in other words, help objects tell their—admittedly truncated—stories. The objects can be turned into lesser versions of what futurist Bruce Sterling called “spimes.”<sup>56</sup> Sterling argued that society is heading toward a new age of technological development in which objects will become interactive and able to communicate their stories with humans. He defines spimes as “manufactured objects whose information support is so overwhelmingly extensive and rich that they are regarded as material instantiations of an immaterial system. Spimes begin and end as data. ... Spimes are sustainable, enhanceable, uniquely identifiable.”<sup>57</sup>

As wide-ranging as that definition may seem, Sterling is describing a rather clear future in which objects speak more with people. Spimes begin and end with data, so the stories they have to tell are comprehensive, ranging from their birth all the way through their death. Their memories will be far better than ours

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as humans, and essential to the future of the spime are the last two words of the above definition: “uniquely identifiable.” For the spime to work, no two objects will have the same story. Even if something is mass-produced, it will no longer be “mass” in today’s sense because it will be assigned an identity, just as RFID tags are already used to affix unique identities to billions of objects.

As Sterling points out, spimes do not exist yet, at least at a widespread level. But he identifies the adoption of RFIDs—or “arphids,” as he calls the tags—as one of the first steps in building a spime future. As I cover throughout this book, examples already exist of pseudo-spimes that use RFID to at least partially communicate objects’ stories, a capability also captured in the related concept of the “blogject” coined by computer scientist Julian Bleeker. The blogject is a portmanteau for “object that blogs” and communicates its state to infrastructure. But, as Bleeker points out, blogjects are about more than just tracking the mobility of an object or collecting sensor data about the environment. Blogjects can potentially rise to “first-class a-list producers of conversations in the same way that human bloggers do—by starting, maintaining and being critical attractors in conversations around topics that have relevance and meaning to others who have a stake in that discussion.”<sup>58</sup> The conversations enabled through RFID sometimes rise to those levels, whether the conversations are about the temperature levels of food or the flows of cars on highway infrastructure.

Many examples of RFID covered throughout these chapters might not quite count as spimes or blogjects, but they represent precursors to a possible future in which the mobility of objects becomes comprehensive stories people can access. The stories then will likely affect decision making, and the stories will often

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focus on mobility and identification data. For instance, when someone uses RFID to reveal the authenticity of a pharmaceutical drug, they access a story that ensures an object remained unspoiled throughout its trajectory through the global supply chain. When someone uses RFID to take inventory and record each site a product passes through, they record a history of a specific objects' mobility. Later in this book, I return to the idea of spimes and blogjects to show how RFID enables objects to speak in new ways. In no small part, the ability to link objects to infrastructure, to give objects voices in an increasingly animated environment, has already been RFID's main contribution to the growth of the Internet of Things.

### **The Infrastructures of RFID**

RFID's role in producing identification data shows how the technology is both a piece of infrastructure and a mobile technology. Infrastructure is a term used widely across multiple disciplines, with similar yet divergent meanings. Sociologists Susan Leigh Star and Karen Ruhleder posited that metaphors of infrastructure often present it as a substrate, or "something upon which something else 'runs' or 'operates.'"<sup>59</sup> They argue, however, that infrastructure is more than just that which supports other operations. Rather, "infrastructure is a fundamentally relational concept. It becomes infrastructure in relation to organized practices."<sup>60</sup> Simply building something does not automatically make it infrastructure. Rather, it becomes infrastructure through relationality that involves material (and/or discursive) structure as well as the practices it shapes. As Brian Larkin puts it, "As physical forms they shape the nature of a network, the speed and direction of its movement, its temporalities, and its vulnerability to breakdown."<sup>61</sup> Infrastructures are not just there; they

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are not neutral. They shape and enable behaviors while being shaped through their use. “Infrastructures are matter that enable the movement of other matter,”<sup>62</sup> and they do so in specific, political ways.

Infrastructures are obviously important, but they are not often flashy. Infrastructures are often designed to remain out of the way and fade into the background.<sup>63</sup> Some infrastructure, such as underground fiber-optic cables, is literally hidden.<sup>64</sup> Other forms of infrastructure, such as roads and cellular networks, become so mundane that people rarely pay attention to them until something goes wrong. Although the invisibility of infrastructure is sometimes overstated,<sup>65</sup> it remains true that many types of infrastructure affect people’s lives in ways they pay little attention to. However, the mundanity of infrastructure masks its vital importance. The interpersonal computer-mediated communication analyzed by media studies scholars relies on large networks of infrastructure;<sup>66</sup> the mobility of people, ideas, and information is reliant on infrastructure; at a slightly more abstract level, economic analyses of trade patterns implicate the transnational infrastructures of the global economy. And equally important, infrastructures directly concern issues of power. Urban studies researchers Steve Graham and Simon Marvin’s groundbreaking work *Splintering Urbanism* showed how “social biases have always been designed into urban infrastructure systems, whether intentionally or unintentionally.”<sup>67</sup> Consequently, infrastructures often reflect and reify existing social relations, ranging from infrastructures of surveillance to infrastructures of mobility or, as I will show with RFID, infrastructures that meet at the convergence of the two.

Of course, one of the challenges of studying infrastructures is that they are often designed to not be noticed. Consequently,

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**Figure 1.1**

An assortment of RFID tags.

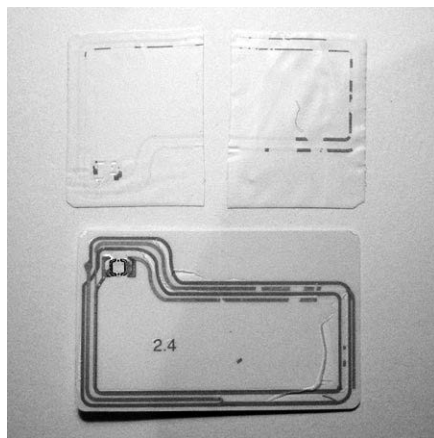
one of the goals of this book is to embrace an “infrastructural imagination” that encourages readers to delve into that which lies below the surface level of our surrounding space. I take that phrase from an interview between Brian Hanrahan and John Durham Peters in which Peters argues that “the infrastructuralist imagination... seeks to appreciate all that is essential and off the radar.”<sup>68</sup> I want to peel back the layers that hide RFID from the world. Peeling back those layers is particularly important for studying RFID because tags come in so many different shapes and sizes. Take the image in figure 1.1 as an example.

That image is a collection of RFID tags I collected in the course of my research. The tags range from small enough to be injected into a dog’s back to larger tags with visibly printed antennae.

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In chapter 3, I go into more detail on the capabilities of different types of RFID, but the important point here is that RFID tags come in many shapes and sizes depending on a variety of factors.

The tags themselves, even when one knows what to look for, can be difficult to identify because they are so varied. Adding a layer of complexity, the small size of RFID tags also lends themselves to some fairly intense forms of the invisibility of infrastructure. Tags can be injected into bodies (both human and animal), embedded in packaging, and sewn inside clothing. Many people reading this book are likely within reach of some kind of RFID embedded in between plastic, whether in the form of a contactless credit card or an access badge of some sort. Take the image in figure 1.2 as another example: a (now obviously broken) Washington, DC, SmarTrip metro card.



**Figure 1.2**

A disassembled DC Metro card that shows the internal RFID antenna. Image credit to Tom Lee.

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The card looks like any other card in someone's wallet, but one can peel back that surface layer to expose an RFID antenna that communicates with the card readers of the DC Metro system. Tearing off that outer plastic and examining the types of communication that occur beneath the surface is part of the infrastructural imagination that shapes this book. Those antennae embedded in plastic communicate; they link bodies' movements to infrastructure. They make each individual passenger uniquely identifiable. They are mobile communication.

### The Structure of This Book

RFID technologies can be found all over the place, from the ears of cattle to the bodies of humans, from the plastic of subway cards to the labels of wine. These tags, regardless of where they are found or how they work, can make objects machine-readable, communicative, and uniquely identifiable. The tags produce data about objects that feed into larger systems for identification and analysis. But RFID is far from the only infrastructure of object identification. Consequently, chapter 2 looks at parallel technologies and links them to the role RFID plays in animating the physical environment. The chapter begins by discussing why barcodes are the most important antecedent technology to RFID and then looks at a related technology of identification that will play a crucial role in the Internet of Things: the IPv6 standard. After discussing related technologies, I then trace the history of RFID back to developments in radar and discuss the birth of the Internet of Things concept and some of the successes and failures of RFID adoption.

Chapter 3 goes into more detail on how RFID works. The chapter is not meant as a technical guide to the technology, and

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I do not go into complicated explanations on the physics of radio waves or the intricacies of antennae design. Rather, I cover topics such as the difference between active and passive tags, RFID frequencies, and types of RFID data to push back against some of the misunderstandings about the technology. I argue that some articles confuse the technical capabilities of different types of RFID in ways that muddle the benefits and drawbacks of RFID adoption. The chapter also explains near-field communication—an emerging type of RFID that links smartphones to material infrastructure through radio waves. While chapter 3 goes into detail about how various types of RFID work, I do so in a way that is hopefully not too dry and will help readers be critical of claims made about what the technology can and cannot do.

Chapters 2 and 3 build a knowledge base about RFID's history and technical capabilities. Chapter 4 uses that base to delve more deeply into the role the technology plays in the Internet of Things, covering different conceptualizations of the Internet of Things and arguing for broad definitions that enable a more holistic understanding of the concept's potential. Additionally, a definition of the Internet of Things that includes “things” that do not have their own internet connection enables a deeper analysis of how object communication affects issues of space and place. Consequently, the chapter covers theories of the merging of physical space and computing before discussing multiple examples of the sometimes mundane, sometimes not, ways RFID is used to enable object communication.

Much of the excitement of the Internet of Things revolves around issues of data. By connecting objects and making them communicate, people will be able to collect data on previously impossible scales. And, going back to the original concept of RFID and the Internet of Things, object communication has always

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been about data. Attaching an RFID tag to everything from a book to a car turns an object into a machine-readable producer of data. Chapter 5 looks at RFID's role in producing data and how the technology both enables and is shaped by discourses about the supposed "big data revolution." The chapter examines the meanings of the word data and the epistemological shifts that accompany some embraces of big data. I then move on to examples of how RFID is used to produce data in diverse ways. The examples, however, do more than just look at different types of RFID data. Rather, the examples show the many factors external to specific technologies—ranging from types of software to regulations to religious texts—that shape what kinds of data are collected, tempering more utopian claims about data "speaking for themselves."

Much of the data shared through RFID is about things. Billions of objects in the supply chain broadcast their identities; temperatures of cold chain transportation are transmitted through RFID and sensors. Other forms of RFID data, however, more significantly implicate issues of privacy and surveillance. As chapter 6 discusses, RFID became a target of privacy advocates in the mid-2000s, and some of the outcry about the implications of the technology likely slowed RFID adoption. The chapter looks at the privacy concerns of RFID in everything from tags on pairs of pants to tags on windshields to the RFID chip inside most passports. Importantly, chapter 6 uses the discussion from chapter 3 (of the affordances of different types of RFID) to push back against some alarmist accounts that overstate the technology's communicative capabilities. The chapter also urges the importance of an infrastructural imagination in understanding the oft-unnoticed types of object communication that play a role in shaping how identification infrastructures function.

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The book concludes with a shorter chapter that looks into the future of RFID's role in the Internet of Things. I avoid making bold predictions about where RFID technologies will be in ten years, in no small part to avoid the embarrassment of being very wrong. But I do put recent developments—including Apple's removal of most near-field communication restrictions, the long-awaited "tipping point" in item-level tagging, and the automation of data collection—in perspective to show why this is an interesting time for infrastructures of identification. For the Internet of Things to reach its predicted potential, the types of object communication covered throughout this book will need to grow. RFID—in no small part because of its ubiquity, cheapness, and promiscuity—will be an enabling technology that gives a voice to billions of objects moving through the world.

### Conclusion

The Internet of Things involves connecting objects and enabling them to communicate in new ways. The concept was first coined in a 1999 presentation about RFID technology, and the concept has matured since then. However, as useful as the concept of the Internet of Things may be at times, it also can hide more than it reveals. Namely, as I discuss in more detail in later chapters, the Internet of Things is almost always framed within a discourse of newness, as a technological development just off in the future and about to happen. That focus on the future can blind people to the many ways billions of objects already communicate directly with identification infrastructure. Transportation infrastructure connects with objects and responds when it senses their presence. In other words, our environment is already filled with connected objects and computing power. The Internet of

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Things in some ways may still be emerging, but in other ways it is already here.

Consequently, the examples of RFID systems I cover throughout this book examine both the mundane and the experimental. I analyze transportation and access infrastructures that have been around since the 1990s. But I also look at RFID systems that are still in the pilot stage and might never achieve commercial viability. Ultimately a key part of what makes RFID such an interesting technology is its ubiquity and promiscuity. Once people know where to look, they can find tags all over the place. As with any relatively new technology, the analysis in this book can provide only a snapshot of a shifting landscape. Some of the topics I discuss will change as the technology matures or is replaced. The general focus of this book on identification and communication, however, will remain vital regardless of what happens in the coming years. For networks of object communication to grow, objects will have to be differentiated in the physical world. RFID is a key piece of how that differentiation happens, a piece that plays an often unacknowledged role in the functioning of everyday life.

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