Introduction

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💽 ignal traffic refers to the movement of electronic media across various parts 🕗 of the planet. It is the aggregate result of a global culture of continuous electronic transmissions. Though electronic signal trafficking can be dated to the rise of telegraphy during the nineteenth century, this book focuses on the contemporary era of media globalization-an era characterized by contradictory global mediascapes and multiple media infrastructures.¹ Today, broadcasting, cable, satellite, Internet, and mobile telephone systems are used simultaneously, and sometimes in coordinated ways, to route signal traffic to and from sites around the world. The content and form of contemporary media-whether television programs or online games-are shaped in relation to the properties and locations of these distribution systems.² Simply put, our current mediascapes would not exist without our current media infrastructures. As a suggestive concept, then, signal traffic demarcates a critical shift away from the analysis of screened content alone and toward an understanding of how content moves through the world and how this movement affects content's form. The chapters in Signal Traffic call attention to the media infrastructures that distribute audiovisual content, the ways industries and people imagine, organize, and use those infrastructures, and the varied scales at which they operate.

Inside this sprawling brick complex in Hamina, Finland (figure I.1), banks of computers process enormous amounts of data. Located in the icy climate of northern Europe, where the cooling of constantly running electronics is more



Figure 1.1. A Google data center sits in the icy landscape of Hamina, Finland, where system operation is more energy efficient.

energy efficient, Google paid \$350 million Euros to transform this site from a paper mill into "one of the most advanced and efficient data centers in the Google fleet."³ The facility, which once employed 650 workers to turn wood into paper, now employs one hundred Google workers to route bits through networks.⁴ Just one node in Google's expansive global infrastructure, the Hamina data center is used to distribute Internet traffic primarily throughout Europe. The emergence of such data centers in sites around the world evinces a series of changes in infrastructures of media distribution. Beefed-up broadband pipelines, cloud computing systems, digital compression techniques, and protocols are now integral to the movement and storage of audiovisual signals worldwide.

Just as a paper mill can be repurposed as a data center, a massive water tower can double as a cell-phone mast. In this scene in Lusaka, Zambia (figure I.2), another kind of infrastructural archaeology surfaces as antennas that relay mobile phone traffic are mounted on a tower used to distribute water. Space atop the water tower is leased to commercial mobile-phone operators who appropriate the tower's height to circulate signals and display giant billboards within new "footprints" or "coverage zones." This layering of an emergent system upon an existing one not only exposes the path dependencies of infrastructural



Figure 1.2. In Lusaka, Zambia, mobile phone providers lease space on water towers to send signals and advertise their services.

formations but also reveals how an established node can be used to generate new markets and economic potentials. The water tower no longer only distributes water: it develops a "second life" by hosting a mobile phone tower. As mobile-phone infrastructure is bundled with water infrastructure, sociocultural and economic activities around this node have the potential to alter and expand. In other places around the world, too, mobile-telephone towers have been propped upon skyscrapers, church steeples, minarets, or giant standalone poles; they are sometimes even camouflaged as trees.⁵ Built environments have been transformed into wireless footprints. Media and communication researchers have begun to explore the sociocultural and economic relations of mobile telephony, but few have considered the complex materialities of its infrastructure.

Finally, this photograph (figure I.3) features the landing station of the first telephone cable across the Pacific, a link that solidified Hawai'i's position as a communications hub during the 1950s and 1960s. Today, fiber-optic cables extend this legacy, shuttling mobile telephone conversations and Internet traffic across O'ahu's shores. This first cable station at Hanauma Bay, buried



Figure 1.3. At Hanauma Bay, Hawai'i, a Cold War-era undersea cable station was buried underground in order to protect it from attack.

underground like many Cold War–era infrastructures, was disguised as part of the hillside to protect it from attack.⁶ The burying of this station was not its only environmental impact: installers had to dynamite their way through a reef to ensure the cable had a safe path out to sea. More than fifty years later, this path has become a corridor of environmental tourism. The hole in the reef, now dubbed the "Telephone Cable Channel," draws scuba divers and snorkelers through one of Hawai'i's foremost nature preserves. The cable, once used to traffic telephone calls, has been repurposed by marine scientists to monitor the undersea environment, sensing aquatic life forms and seismic movements on the ocean floor. Critical studies of such sites draw attention to media infrastructures' entanglements with environmental and geopolitical conditions, from the moment of installation through their residual uses.⁷

In this book we conceptualize sites such as data centers, mobile-telephone towers, and undersea cables as *media infrastructures*—situated sociotechnical systems that are designed and configured to support the distribution of audiovisual signal traffic. Media infrastructures are concentrated in particular locations and spread across vast distances. They are highly automated, relying on sensors and remote control, and require human labor for their design, installation, maintenance, and operation. They operate ethereally, transmitting signals at the speed of light, and are grounded in bunker-like facilities heavily secured on earth. Media infrastructures are material forms as well as discursive constructions. They are owned by public entities and private companies and are the products of design schemes, regulatory policies, collective imaginaries, and repetitive use. Interwoven within political-economic agendas, media infrastructures have historically been used in efforts to claim and reorganize territories and temporal relations.⁸ Their material dependence on lands, raw materials, and energy imbricates them within issues of finance, urban planning, and natural-resource development.

What can media and communication studies gain by adopting an *infrastructural disposition*? First, a focus on infrastructure foregrounds *processes of distribu-tion* that have taken a backseat in humanities-based research on media culture, which until recently has tended to prioritize processes of production and consumption, encoding and decoding, and textual interpretation.⁹ In humanistic media studies there is a serious disjuncture between the amount of scholarly attention dedicated to screened entertainment and the amount devoted to understanding the infrastructures that distribute the signals that become entertainment, whether they exist under the sea, across lands, or "in the cloud."¹⁰ Beyond a concern with the physical systems of media distribution, critical analysis of infrastructure involves interrogating the standards and formats necessary to route content across these systems, whether compression technologies or Internet protocols.

Second, a focus on infrastructure brings into relief the unique materialities of media distribution-the resources, technologies, labor, and relations that are required to shape, energize, and sustain the distribution of audiovisual signal traffic on global, national, and local scales. Infrastructures encompass hardware and software, spectacular installations and imperceptible processes, synthetic objects and human personnel, rural and urban environments. Drawing from work in new materialisms and feminist science and technology studies, media infrastructure studies set out to understand the materialities of things, sites, people, and processes that locate media distribution within systems of power.¹¹ As Diana Coole and Samantha Frost write, "Materiality is always something more than 'mere' matter: an excess, force, vitality, relationality, or difference that renders matter active, self-creative, productive, unproductive."¹² Using a combination of discursive, archaeological, phenomenological, and ethnographic approaches, Signal Traffic's contributors investigate the complex materialisms of infrastructure in a range of locations, from architectural designs in New York City to cybercafés in Turkey, from mobile phone networks in the Middle East to

undersea cables in the Pacific. By exploring material forms and practices across national contexts, their chapters bring new settings, objects, and stakeholders into the arena of media and communication research.

Third, a focus on infrastructure compels critical assessment of the relation between technological literacies and public involvement in infrastructure development, regulation, and use. Arguably, one of the reasons that infrastructures and "public utilities" have been so steadily privatized by governments over the past several decades is a lack of citizen knowledge about and interest in such systems. As scholars have observed, infrastructures are defined by their invisibility: most of us hardly notice them until they fail or break down.¹³ Public access to technical knowledge about infrastructures is not equal; rather, it is guided and constrained by social hierarchies of gender, race/ethnicity, class, generation, and nation. Capitalist societies generally educate people to appreciate the "conveniences" and "choices" of modern consumer technologies, but to remain blind to the infrastructures that support them. As a result, infrastructural changes often occur quickly and without notice, short-circuiting citizen-users' ability to participate in system development. What would it take to arouse greater public interest in media infrastructures? What kinds of scholarship and teaching would help to catalyze and sustain broader citizen involvement in infrastructural matters? It is our hope that the critical study of media infrastructures will deepen scholarly and public engagement with such questions.

Paths to Media Infrastructure Studies

The kinds of systems we define as media infrastructures have historically been referred to by media and communication scholars as *telecommunication networks*. Key research on networks from the telegraph to the Internet have been penned by Harold Innis, James Carey, Herbert Schiller, Benedict Anderson, Armand Mattelart, Manuel Castells, Monroe Price, Jill Hills, and Dan Schiller, among others.¹⁴ Collectively, their scholarship has described the political and economic strategies and regulatory structures that undergird the development of national and international telecommunication systems, the cultural impacts of their emergence, and the imperializing dimensions of their use. This work has articulated the rise of telecommunication networks with the administrative maneuvers of states, governmental agencies and multinational corporations, processes of modernization, urbanization, and globalization, and various stages and forms of capitalism. In other fields, such as history, science and technology studies, geography, and anthropology, scholars have approached infrastructures

as large technical systems, urbanization campaigns, and sites of material culture. This interdisciplinary scholarship, which we call *critical infrastructure studies*, draws upon methodologies and frameworks across the humanities and social sciences to historicize and analyze infrastructures ranging from bridges to power grids, from railways to sewer systems.¹⁵

Building upon this research, we understand media infrastructures not only as telecommunication networks owned and operated by governments, militaries, and corporations, but as complex material formations that operate at multiple scales. We describe these formations using a relational approach that recognizes the industrial, physical, and organizational interconnections of media infrastructures with other systems. We address the *different and uneven conditions* that shape and characterize media infrastructures around the world as well as the *labor, maintenance, and repair* required to build and sustain them. Our approach also considers the natural resources that media infrastructures require and the environmental impacts they produce. We further attend to the myriad ways people encounter, perceive, and use media infrastructure—that is, the *affective* relations they generate and become part of. Finally, critical studies of media infrastructures, we believe, can provide a platform fo<mark>r *innovative methodologie*s by</mark> activating and combining approaches such as archaeology, political economy, phenomenology, ethnography, and discourse analysis. In the sections that follow, we further discuss these critical issues and some of the research that informs them.

Scale

One of the most distinctive aspects of media infrastructures is their scale: they span continents, oceans, and atmospheres, and can leave long-lasting traces. Some work in critical infrastructure studies foregrounds the significance of scale by documenting the relations between large technical systems and processes of industrialization. In his influential book *Networks of Power*, Thomas Parke Hughes uses the case of electrical systems to extrapolate several phases of infrastructure formation, including invention and development, transfer between regions and societies, system growth, and the attainment of technological momentum.¹⁶ By establishing a general framework for studying infrastructures as large technical systems, Hughes inspired histories of other such systems, including railroads, telecommunication, air-traffic control, and gas networks.¹⁷ Historians of nineteenth-century culture and technology, for instance, have described how large networks of transportation and communication "annihilated" space and time, facilitated standardization, and reshaped everyday life. Building on the work of Hughes and others, Paul Edwards argues that large-scale infrastructures are core to the experience of modernity, observing, "To be modern is to live within and by means of infrastructures."¹⁸ Yet Edwards insists that mesoscale studies of infrastructure, such as Hughes's, tend to generalize about and normalize conditions of modernity, failing to account for the fact that people often "inhabit, uneasily, the intersection of . . . multiple scales."¹⁹ *Signal Traffic* heeds Edwards's call for more macroscale and microscale studies that explore a broader range of national and user contexts and attend to variable infrastructural conditions.

Approaching infrastructure across different scales involves shifting away from thinking about infrastructures solely as centrally organized, large-scale technical systems and recognizing them as part of multivalent sociotechnical relations. Rather than take an overarching or mesoscale view, digital media and informatics researchers have honed in on the macroscale and microscale elements of networks, protocols, and bits, investigating material-semiotic and experiential dimensions of digital technologies. Foundational studies by Wendy Chun and Alexander Galloway, for instance, have foregrounded the macrolevel fiber-optic networks and microscale protocols through which data circulate, respectively.²⁰ Jean-François Blanchette has delved into the nitty-gritty of computing by examining bits, insisting that they "cannot escape the material constraints of the physical devices that manipulate, store and exchange them."²¹ These works, among others, have contributed to emergent fields of software studies and platform studies, the latter of which examines the hardware on which software runs and digital media are materialized.²²

In an effort to recognize the range of scales at which infrastructures operate, the chapters here investigate the dynamic components of media infrastructures in ways that enrich and deepen macroscale and microscale analysis. Building upon Galloway's research, in this book Paul Dourish explores key design issues in the development of Internet protocols and demonstrates how and why the size of data packets traversing through networks matters. Decisions about whether a message should be broken into 64-byte or 32-byte "payloads," he reveals, are related to the divergent characteristics of national infrastructures and geographies. Jonathan Sterne's chapter similarly moves between scales, charting the historical emergence of microscale compression technologies in relation to macroscale transmission lines. As these chapters explore how microscale processes and macroscale architectures inflect one another, they bring the complex materialities and relationalities of media infrastructures into focus.

Relationality

In addition to recognizing the multiscalar dimensions of infrastructures, Signal *Traffic*'s contributors emphasize the layering or bundling of distinct systems (such as that of water and mobile telephony discussed earlier) as well as the interconnections between infrastructures, environments, and users. Researchers in science and technology studies approach infrastructures as dynamic sociotechnical formations and organizations rather than as isolated or static machines. According to Susan Leigh Star and Karen Ruhleder, infrastructure encompasses both technical bases and social arrangements, extends beyond single events and sites, connects with existing practices and standards, and must be learned and naturalized over time by users.²³ As such, infrastructure is fundamentally a relational concept rather than a concrete object; it "is something that emerges for people in practice, [and is] connected to activities and structures."24 Blending approaches from sociology, communication, and anthropology, Susan Leigh Star and Geoffrey Bowker have revealed how infrastructures are embedded in everyday practice, foregrounding the hidden labor they rely upon as well as how they are contingent on social structures. For them, infrastructure refers not only to tubes and pipes but includes "soft" systems of organization and knowledge, ranging from professional societies to classificatory procedures. Infrastructure studies, their work demonstrates, is not simply a quest to understand large technical systems; rather, it explores processes and changes at a "mundane scale" and treats them as part of the building of organizations and production of knowledge.²⁵

Some research on infrastructure, including that of Bowker and Star, builds upon and extends Actor-Network Theory (ANT), developed by Michael Callon, John Law, and Bruno Latour.²⁶ ANT insists on the complex relationalities of social and technical systems, and it troubles the tendency to reduce or ignore the agential aspects of nonhuman objects as well as the responsibilities that humans delegate to them.²⁷ Researchers in the areas of organizational communication and informatics have drawn upon ANT to create an interdisciplinary field known as *information infrastructure*. Work in this field has set out to rethink the ontology of infrastructures, critiquing assumptions of their stability and manageability, and treating infrastructures as "performative forces that evolve dynamically" and as phenomena that are "generated and regenerated in openended relationships."²⁸

Other theorizations of relationality have emerged in recent work on "new materialisms," which, like ANT, emphasizes complex relationships between human and nonhuman actants. Karen Barad's reconceptualization of materiality,

for example, tasks us to see the material world not as simply given or independent but as ontologically entangled with and produced through the very apparatuses we use to make sense of it.²⁹ Inspired by Barad, Coole and Frost argue that we must think about causation in much more complex ways and "recognize that phenomena are caught in a multitude of interlocking systems and forces and to consider anew the location and nature of capacities for agency."30 Objects have a life, according to vital materialist Jane Bennett, because of their capacity to make a difference in the world and to have effects. Approaching the power grid in a very different way than Thomas Hughes, Bennett conceptualizes it as an assemblage or "federation of actants," explaining: "To the vital materialist the electrical grid is . . . understood as a volatile mix of coal, sweat, electromagnetic fields, computer programs, electron streams, profit motives, heat, lifestyles, nuclear fuel, plastic, fantasies of mastery, static, legislation, water, economic theory, wire, and wood-to name just some of the actants."³¹ After uncovering the litany of causes and effects of power outages and blackouts in North America, she insists, "humans are not the sole or most profound actants in assemblages."32

Feminist critics of science and technology such as Donna Haraway, Rosi Braidotti, Lucy Suchman, and Chela Sandoval have for decades been insisting upon the need for ontologies and epistemologies that recognize a broader and more diverse spectrum of human/nonhuman hybrids, interactions, and relations. Emerging research in ANT, new/vital materialisms, and object-oriented ontologies reveals that a broader intellectual quorum has formed around the idea that objects matter.³³ Although recent work in the areas of object-oriented ontologies, media archaeology, and platform studies addresses the materiality of technological systems, much of it overlooks feminist critiques of technology, power, and difference that are integral to our conceptualization of media infrastructures. Tarleton Gillespie's astute interrogation of the "politics of platforms," however, serves as an exception, as it confronts the ways power and discourse help to constitute what a "platform" is and who controls it.³⁴ Though only some of the chapters in this book are influenced by research in these emergent fields, we anticipate that future research on media infrastructures will engage more directly with this work as it challenges us to recognize a more extensive field of actants and relations in media and communication studies. Authors in this collection, for instance, show that in some parts of the world Internet and mobile-phone infrastructure could not function without water, state surveillance could not occur without land and spectrum, and data centers could not function without the sun. In such scenarios, humans are but one part of broader infrastructural formations.

Difference and Unevenness

As Signal Traffic's contributors examine media infrastructures across scales and as complex relationalities, they also explore how these extensive systems emerge in different parts of the world. What is often missing from mesoscale accounts is a detailed investigation of the varied ways that infrastructures intersect with cultures of everyday life as well as how their implementation and use fluctuates across industrialized and developing regions, rich and poor neighborhoods, and urban and rural settings. Media infrastructures may be centrally owned by nation-states or corporations, but at their edges they are imagined, arranged, and adopted in different ways by people or "end-users." As Colin McFarlane and Jonathan Rutherford have argued, we must provincialize the study of infrastructure and examine how it matters differently to various groups across space and time.³⁵ Toward that end, some chapters of this collection explore what media infrastructures look like or feel like from a peoples' or populist perspective.³⁶ Lisa Parks's chapter, for instance, considers how people's use of the Internet in rural Zambia is punctuated by variable access to electricity and water. Helga Tawil-Souri's chapter explores how Palestinians experience the political topography of the occupied territories in their encounters with mobile telephony.

In an effort to highlight the differential dimensions of infrastructures, urban studies scholars have conducted fieldwork in cities around the world. In their pathbreaking book, *Splintering Urbanism*, Stephen Graham and Simon Marvin demonstrate how networked infrastructures across sectors of energy, telecommunication, transportation, and water have been organized in ways that support the privatization of public utilities and create urban fragmentation.³⁷ Immersing readers in specific infrastructure nodes in cities north and south, Graham and Marvin challenge us to develop site-specific investigations of the "massive technical systems that interlace, infuse and underpin cities and urban life" and to participate in the politics of their future imagining and formation.³⁸ Their work offers a crucial model for studying infrastructures across global/national/local contexts, in relational ways, and in close-up (in situ), and informs much of the research in this book. Extending the focus beyond urban settings, *Signal Traffic*'s contributors offer studies of rural or transitional areas, bringing new ecologies, technological objects, and communities into infrastructure research.³⁹

As infrastructures emerge in relation to conditions of difference and unevenness, they are fraught within relationships of power. The organization and use of infrastructures have the potential to reinforce or reverse unjust social relations. Insisting upon the need to address the politics of digital networks, scholars such

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as Mark Poster and Manuel Castells have argued that the Internet augured a new "mode of information"⁴⁰ or "space of flows"⁴¹ permeated by power differentials. Corresponding research on "cyberinfrastructure" has emphasized the levels of technological access and literacy that digital systems require and the new divides they can create.⁴² Drilling down on this point, researchers have also confronted the politics of the "digital divide," explicating how and why access to media infrastructures relates to disenfranchisement and exclusion.⁴³ This question of who has access to digital technologies arguably remains one of the most pressing issues of our times, and an entire field called Information and Communications Technologies for Development (ICTD) has emerged to try and tackle it.

Even with infrastructures in place and broadly accessible, there is no guarantee that they will function properly or serve people's interests. As anthropologists Dennis Rogers and Bruce O'Neill point out, infrastructures also can have deleterious effects, enforcing social norms or enacting physical and emotional harm.⁴⁴ Rogers and O'Neill argue that in certain situations "infrastructure is not just a material embodiment of violence (structural or otherwise), but often its instrumental medium."⁴⁵ More than simply to divide people, infrastructures can be used to exert force or injure. Turning off the electrical grid during times of war means civilians freeze. Making telecommunication costly can shut the poor off from emergency services and put lives in jeopardy. The shift from a normalized condition of infrastructural service and connection to one of disruption and disconnection, whether because of war, weather, or cost, can create profound physical and psychic experiences for communities and individuals alike.

Labor/Repair/Maintenance

Studies of media infrastructure also must take into account labor, maintenance, and repair, since system operations depend on these practices. As Nigel Thrift suggests, an infrastructure must be produced and reproduced through social practices: "[it] has precisely to be performative, if it is to become reliably repetitive."⁴⁶ Research by Carolyn Marvin, Greg Downey, and Brian Larkin has addressed the performative labor of infrastructure by exploring, respectively, electricians' imaginings of early power grids, the dynamic movements of messenger boys who fueled early telegraphy systems, and the colonialists who built bridges and radio networks to extend their ways of life into Africa.⁴⁷ Sarah Harris's chapter builds upon this research by demonstrating how cybercafé operators' daily routines become part of Internet infrastructure in Turkey. Turkish cybercafé operators are able to maintain Internet connectivity, Harris suggests,

only by constantly renegotiating and selectively enforcing state censorship policies in their neighborhood shops.

The operation of media infrastructures is contingent not only on the labor of those who operate or maintain them on a daily basis but also on those who build end-devices, whether smart phones, laptops, or high-definition TVs. In *Below the Line*, Vicki Mayer uncovers the life worlds of TV-set manufacturers in Brazil, revealing that it is impossible to separate the global distribution of entertainment media from those who spend tireless hours on assembly lines manufacturing the electronic devices used to consume it. Charles Acland's chapter in this book foregrounds the fact that consumer electronics are vital to the transmedia era and suggests that they support the "platform plenitude" and "branded viewing experiences" of a "wired class." Combined, Mayer's and Acland's work suggests the need for further research on the manual and intellectual labor and industrial conditions upon which media infrastructures are built.

Given the growing economic investment in and cultural fascination with audiovisual infrastructures, platforms, and devices, it is important to consider what happens when such systems malfunction or fail.⁴⁸ In *Disrupted Cities: When* Infrastructure Fails, Stephen Graham argues that studying moments of breakdown or failure might be the most appropriate heuristic device for infrastructural understanding, for it is "perhaps the most powerful way of really penetrating and problematizing those very normalities of flow and circulation."49 Moments of failure, in other words, can help to reveal or b<mark>ring into consciousness the myriad</mark> micro- and macro-level conditions and perceptions of "flow and circulation" that are needed to sustain infrastructural operations in the first place. Consistent with this contention, Steven Jackson suggests an epistemic shift toward what he calls "broken world thinking," asserting that "breakdown, dissolution, and change, rather than innovation, development, or design . . . are the key themes and problems facing new media and technology scholarship today."50 Research in this area suggests that infrastructural breakdowns and acts of repair should be thought about as a "normal" part of technological processes and as opportunities for retooling social relations.⁵¹

Natural Resources/Environment

Another of this book's critical interventions is to focus further attention on the relationship between media infrastructures, natural resources, and environments. As work by Harold Innis and James Carey has shown, the organization and physical arrangement of media infrastructures demand critical thinking

across sectors of energy, transportation, agriculture, natural resources, and trade. Richard Maxwell and Toby Miller's *Greening the Media* details the heavy resource demands and environmental impacts of the contemporary global media economy: they report that in 2007 media technologies were responsible for between 2.5 percent and 3 percent of the world's greenhouse gas emissions, a figure that has only increased with the expansion of Internet infrastructure, emergence of new data centers, and intensified production and use of consumer electronics.⁵² As Nadia Bozak argues in her important book *The Cinematic* Footprint, "The image—cinematic, photographic, digital, or analog—is...materially and economically inseparable from the biophysical environment."53 We would add to Bozak's claim that image (and sound) distribution-signal trafficking-is also inseparable from the biophysical environment. Signal Traffic's contributors not only consider the resource requirements of media infrastructures, they also explore how the availability of water, land, electricity, and spectrum can determine the geographic positioning and physical organization of infrastructures such as transoceanic cables, networked data centers, and mobile-phone towers.

In this way, the critical study of media infrastructures is tied directly to the emergent field of environmental media studies as it considers where the materials and energy needed to build, operate, and sustain massive systems of content distribution come from and evaluates the impacts of those systems on environs in different parts of the world.⁵⁴ In pursuing such issues, research in this book also sets out to complicate epistemological divides between technology and nature, human and nonhuman, material and immaterial, suggesting that such categories are relationally defined and materially intertwined. By emphasizing the entanglement of media infrastructures and environments, this book embraces Sarah Kember and Joanna Zylinska's provocative suggestion that "mediation can be seen as another term for 'life,' for being-in and emerging-with the world."55 In practice, this approach troubles any clear distinction between what we consider to be media infrastructure, such as a broadcast transmitter, and sites and processes typically thought of as its "environment." Infrastructures and environments dynamically mediate and remediate one another. Ashley Carse argues that as natural environments are increasingly shaped by human action, phenomena such as rivers and forests have been transformed into systems of human imagination and intervention, rendering nature itself infrastructural.⁵⁶ This shift raises questions such as: How do the rains in rural Zambia or the rivers in Oregon become infrastructural for media circulation? What kinds of media distribution do these "natural" environments support? How are nonhuman forms of life affected by the presence of media infrastructures?

Affect

In addition to exploring the relationship between media infrastructures, natural resources, and the environment, infrastructure can be studied as part of an "affective turn."⁵⁷ In their introduction to *The Affect Theory Reader*, Greg Siegworth and Melissa Gregg point out that "affect" has a complex history with many valences. Drawing upon phenomenological philosophies, they define affect generally as "a gradient of bodily capacity—a supple incrementalism of evermodulating force-relations—that rises and falls not only along various rhythms and modalities of encounter but also through the troughs and sieves of sensation and sensibility."⁵⁸ To be sure, infrastructures are part of such "force-relations," since our encounters with them can elicit different dispositions, rhythms, structures of feeling, moods, and sensations. For many people, the default affective response to infrastructure might be apathy, disinterest, or indifference, but it is also possible that a broad spectrum of infrastructure-related affects remains unspoken and unknown simply because certain questions have not been asked.

Darin Barney's ethnographic study of "grain-handling technologies" and "railway branchlines" on the Canadian prairies is an exemplary study of infrastructure and affect. Immersing himself in the life worlds of small-town grain farmers, Barney describes grain silos and railroads as places of focused attention and exchange in rural communities.⁵⁹ One of his informants describes the grain elevator at Fairlight, Saskatchewan, as "a place to hear the news—news of births and deaths and war and peace. It's been a place to debate politics, wheat prices, wheat boards and hockey; a place to shake the loneliness of life on the land."60 The takeover of these facilities by big agribusiness during the past two decades, Barney explains, not only resulted in the gradual demolition and replacement of these infrastructure sites with more "efficient" farming equipment, but the shift also generated feelings of isolation and frustration as farmers sat in long lines alone in their trucks waiting to unload grain in conglomerates' new "through-put terminals." By shedding light on "the complex ways in which infrastructural technologies mediate the organization of social and political life," Barney's research brings affective dimensions of infrastructures to the surface, while bringing different objects and actants into the repertoire of media studies.⁶¹

A phenomenology of infrastructure and affect might begin by excavating the various dispositions, feelings, moods, or sensations people experience during encounters with infrastructural objects, sites, and processes. This exercise could unfold along a continuum that recognizes, on one end, the general tendency of infrastructures to normalize behavior (such that they become relatively invisible, unnoticed, or internalized), and, on the other, as the potential for the disruption of that normalization, which can occur during instances of inaccessibility, breakdown, replacement, or reinvention. By sketching out this continuum, we build upon Wendy Chun's crucial work on the Internet's relation to control and freedom and point to the cornucopia of infrastructural affects that lies in the gray zone between them. We hope that this will catalyze further thinking about the range of ways people perceive and experience infrastructures in everyday life and how these experiences differentially orient or position people in the world.

Innovative Methodologies

Finally, in addition to approaching media infrastructure as a site for critical thinking about issues of scale, relationality, difference and unevenness, labor and maintenance, natural resources, and affect, we think of the concept as a nesting ground for innovative research methodologies. As Bowker, et al. have argued, "Infrastructure studies require drawing together methods that are equal to the ambitions of its phenomenon."62 And as Brian Larkin suggests, "The sheer diversity of ways to conceive of and analyze infrastructures . . . cumulatively point[s] to the productive instability of the basic unit of research."63 Like infrastructures, research units and methods are dynamic fields that take time to emerge and solidify. Signal Traffic brings together projects that use qualitative methodologies such as discourse analysis, ethnography, archaeology, archival research, industry analysis, and fieldwork. As multidisciplinary scholars situated primarily in the humanities, our contributors also bring a range of critical theories to bear on the study of media infrastructures, drawing from poststructuralist theories of power, postcolonial criticism, science and technology studies, feminist theory, historiography, and cultural geography. The result is a broad tapestry of approaches. While some chapters delineate the conceptualization and historicization of infrastructural processes, others examine specific infrastructure sites or objects. While some focus on centers of infrastructural activity, others explore infrastructural edges, outskirts, or fringes as well as those Susan Leigh Star once referred to as the "orphans of infrastructure."⁶⁴ And while some focus on imperceptible, microscale phenomena, others take a step back and provide a big picture. Since media infrastructures are configured in relation to and sometimes literally built on top of other infrastructures, they also invite archaeological approaches. In her chapter of this book Shannon Mattern engages with such approaches to conceptualize what she calls "the deep time of media infrastructure."

Collectively, the work in Signal Traffic sets out to extend materialist studies of media technologies by rethinking and expanding the concept of infrastructure, exploring physical installations, objects, sites, and processes in detail, analyzing industrial transitions, and probing the sociohistorical conditions and power relations that give shape to particular infrastructural formations. Contributors approach the global mediascape as a contradictory and contested domain that must be engaged in multiple ways, from historical, political economic, and sociotechnical perspectives. They explore media infrastructures from the top down and the bottom up, in urban and rural space, and in high- and low-tech conditions. They are mindful of blockages as well as flows, and pay attention to the intersections of meso, macro, and micro scales and processes. The book features field-based ethnographies and archival research alongside studies of industrial forces, technical design, and labor. It explores contemporary media infrastructures such as the Internet and mobile phone networks in relation to water systems, solar power, and human energy. And as the book traces the emergence of infrastructural hardware and installations, it also includes discussions of "soft" infrastructures such as daily routines, marketing, and knowledge practices. Signal Traffic engages with media infrastructure as a concept and material formation, positions it in relation to the politics of difference, and tracks it across different parts of the world, from Sweden to Palestine, from Turkey to Zambia

The Collection

Signal Traffic is organized into three parts. The first, "Compression, Storage, Distribution," features historical and contemporary conceptualizations of media infrastructures as well as analyses of the changing capacities to format, store, and distribute media, whether on disks, through cables, or in clouds. The section opens with Jonathan Sterne's genealogy of media compression techniques and their relation to infrastructures that have historically been developed and scaled to carry or transmit certain loads or capacities. Sterne suggests that by examining compression—a process that accommodates signals to infrastructures—it is possible to rethink and rewrite media history away from a general history of verisimilitude and toward a general history of compression. This historiographic intervention might turn further attention to experiences and aesthetics that emerge around media in limited definition. It might also facilitate an understanding of the ways that compression both renders representation adequate to infrastructure and exposes the limits of transmission. In the end, Sterne observes, compression techniques also work upon infrastructures, making them adequate to the representational loads that pass through them. Using examples ranging from audio compressors to the optical telegraph, Sterne demonstrates that content and infrastructure exist in relations of "circular causality."

Also exploring the relationship between media content and the capacity of hard infrastructure, Nicole Starosielski's chapter, "Fixed Flow: Undersea Cables as Media Infrastructure," offers a framework for understanding how particular technologies, social practices, and natural environments can be conceptualized as media infrastructures. Drawing from work by Susan Leigh Star and Karen Ruhleder, she develops a relational approach to media infrastructure that delineates the multiple routes and effects of global undersea cable networks. Her chapter describes five of the ways undersea cables function as a media infrastructure: they become resources for media activity; alter our everyday experience of media temporality; shape our susceptibility to media censorship and surveillance; solidify global relationships of media power; and serve as a platform where publics can affect the dissemination of media content.

Shifting the focus from transoceanic cables to data centers and cloud computing, Jennifer Holt and Patrick Vonderau's chapter explores how recent depictions of data-center visibility function both as a mode of claiming corporate territory and as an obfuscation of the less picturesque dimensions of cloud infrastructure. As Holt and Vonderau excavate the material support systems, standards, protocols, and constraints of cloud computing, they suggest that analyzing media infrastructure industries, such as the companies that run cloud systems, presents particular challenges for researchers. According to Holt and Vonderau, the structural convergence and functional heterogeneity of media make it difficult to apply some of the tried and true concepts in media and communication studies, such as the distinction between public and private. Using the Swedish data center as an example, Holt and Vonderau decipher the backend of Internet architecture and data-trafficking policies, and they highlight the importance of a relational perspective in understanding data centers as dynamic infrastructure nodes.

In "Deep Time of Media Infrastructure" Shannon Mattern establishes the significance of historical media infrastructures that precede the digital era. Adopting a media archaeological approach, Mattern explores how historical networks layered in urban space shape contemporary media systems. These networks extend back far beyond nineteenth-century telegraph wires to include much earlier Greek-inspired aural, inscriptive, and architectural forms. Suggesting that research on early media infrastructures can usefully inform studies of the media city, which typically begin with modern media and rarely include

discussions of infrastructure, Mattern delineates a number of potential interdisciplinary engagements for media infrastructure studies, ranging from geology to architectural history. Her chapter closes with an important discussion of what media studies can gain from further engagement with archaeological and infrastructural research.

The book's second part, "Resources, Environments, Geopolitics," features a series of site-specific case studies that explore how different configurations of energy, territory, state power, and local practices affect the shape and form of infrastructures as well as knowledge about and access to them. The part begins with Lisa Parks's chapter "Water, Energy, Access: Materializing the Internet in Rural Zambia." Drawing on ethnographic fieldwork, Parks describes a particular rural configuration of Internet infrastructure and shows that access in this location is contingent on water resources, which not only generate hydroelectricity for the Zambian power grid but are also necessary for prospective Internet users' everyday survival in the community of Macha, Zambia. Her chapter foregrounds the struggles and contestations that are part of infrastructure development; the energy and biopower that infrastructures rely on; the relationality of water, transportation, and information systems; and the alternate ways that people imagine, use, or respond to infrastructure, which may range from intense curiosity to patent disinterest.

Also concerned with the topic of energy, Toby Miller's chapter, "The Art of Waste: Contemporary Culture and Unsustainable Energy Use," provocatively challenges media and cultural studies to confront the environmental impacts of the global digital economy. After critiquing an array of intellectual and corporate discourses that celebrate the beneficence of digital technologies, Miller proposes what he calls the "art of waste" and brings a discussion of e-waste together with critiques of the art of labor and the cognitariat. As he insists, "rather than seeing new communication technologies as magical agents that can produce market equilibrium and hence individual and collective happiness, we should note their other impacts." The chapter concludes with a discussion of e-waste–related art projects, which, Miller argues, have the capacity "to exemplify and criticize a state of affairs that must not be allowed to continue." Miller's chapter thus addresses macrolevel environmental and resource questions that underpin the critical study of media infrastructures.

Weaving geopolitics into this part's discussion of energy resources and media infrastructures, Helga Tawil-Souri's chapter details the conditions and contestations underlying cellular phone infrastructures in Israel-Palestine. As she shows how cellular infrastructures in the occupied territories are dynamic manifestations of territorial disputes and tensions, Tawil-Souri argues that the arrangement of telecommunication systems is not merely a metaphor for the conflict; rather, "it is the conflict in material form." Her chapter focuses on three locations—Migron, Ramallah, and Qalandia—and describes the material infrastructures and regulatory regimes that shape conditions in each. Rather than connecting people, she argues, these infrastructures are critical dimensions of state power and territoriality, and as such they function in ways that divide and disconnect.

The book's third part, "Content, Protocols, Platforms," opens with Paul Dourish's meticulous analysis of the materialities of Internet protocols. Returning to some of the issues addressed in Sterne's chapter, Dourish focuses on the relationship between content and conduit, which involves both the compression and modulation of signals. Dourish argues that we need to look not only at the materialities of hard infrastructural elements-from buildings to antennaebut also at the materialities of protocols themselves. He directs attention to the relationships between infrastructures and experience, and the micro-level processes by which digital experiences are produced. To address these concerns, Dourish details the development of Internet routing protocols, tracing how they tie networks together and mediate between hard infrastructure and the circulation of content. He contrasts two different protocols, the Routing Information Protocol and the Exterior Gateway Protocol, which emerged in different historical moments and cultural conditions. Examining the social construction of these network protocols, he reminds us, can help us to differentiate the actual Internet-which grows out of specific material constraints-from a possible or imagined Internet.

Also concerned with the issue of Internet protocols, Sarah Harris's chapter, "Service Providers as Digital Media Infrastructure: Turkey's Cybercafé Operators," approaches the topic in a different manner, focusing on circumvention practices in Turkey. Building upon the literature on infrastructural labor, Harris documents the critical role of service providers in the development of today's digital media systems. She illustrates how an ethnographic approach to media infrastructures helps to connect hard infrastructural forms, such as wires, transmissions towers, and buildings, with soft infrastructural forms, including institutions, protocols, and social practices. Harris suggests that the work of Turkey's cybercafé operators forms a key component of Internet infrastructure, critically shaping the social topography of media in the country. The cafés and their operators coordinate disparate technologies and communities and are sites where different protocols are negotiated. At the same time, Harris shows, in these locations state infrastructural control, surveillance, and censorship can be undermined. Also delving into particular protocols and platforms, Christian Sandvig's chapter, "The Internet as the Anti-Television: Distribution Infrastructure as Culture and Power," investigates the architecture used to distribute video over the Internet. Noting the unprecedented volume of online video that now circulates, Sandvig suggests that this distribution has "enabled a radical approach" by generating forms of labor and content that traditional media industries have never seen before. Suggesting that "television and Internet traffic were at first like oil and water," he explores how computer pioneers thought about television in the 1960s and charts a path to more recent practices of caching, streaming, and multicasting. The case of Internet video distribution, he argues, reveals how crucial the study of infrastructure is to understanding the shape, form, and function of media technologies.

Concluding the book, Charles R. Acland's chapter, "Consumer Electronics and the Building of an Entertainment Infrastructure," shifts the discussion away from Internet protocols and describes an emergent constellation of protocols and platforms within contemporary Hollywood. Returning to issues raised by Holt and Vonderau and Starosielski in the book's first part, Acland's chapter explores how Hollywood's "technological tentpoles"—films that strategically promote cross-media commodities and new generations of devices, platforms, and hardware—serve as vehicles for the advancement of a broader technological system. As Acland puts it, a "dispersed network of devices forms an entertainment and informational infrastructure upon which dominant cultural and economic practices transpire." Moving between entertainment industry events and a proliferating field of consumer electronics, Acland shows how audiovisual infrastructure is a product not only of economic priorities, but also of the conceptual frames that are circulated about them.

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