CHAPTER 10

The Internet as the Anti-Television

Distribution Infrastructure as Culture and Power

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In a prank circulating on the Internet in 2015, the victim is presented with a link to a video with an attention-grabbing title. When clicked, the screen shows the familiar rotating circular pattern of dots that convey the video is loading: a "wait indicator" in the jargon of human-computer interaction. The text "Buffering Video . . ." also appears. This video is actually a looped shot of the wait indicator itself. There is nothing but the wait indicator. In one YouTube version of this prank, a commenter wrote: "This must be the most watched thing on all of YouTube."[1]

If the reader feels the pain of this commenter, he or she might be surprised to know that videos buffer for reasons that are quite different from those most viewers expect. This chapter investigates the invisible infrastructure that delivers video over the Internet and argues that the availability and quality of video on the Internet are significant new political and economic battlegrounds where culture is controlled. The case of Internet video distribution also makes clear that the *infrastructure of distribution* is a crucial site for the analysis of media technologies. Focusing on infrastructure (after Star[2]) is also an essential task for those who hope to know and to change media and technology.[3]

Distribution asks us to revisit a classic question of media studies: How does the medium affect the content? This chapter will demonstrate that the Internet was originally conceived of as the opposite of television: the anti-television. Over the course of several decades, however, the Internet was technologically retrofitted and transformed to make video distribution possible. Embedded in this transformation were competing ideas about what content and which audiences are valuable, and indeed how culture itself ought to work. The selection of videos available on the Internet today—and how that video looks—result from purposeful decisions made by actors who hoped that either the model of television or the Internet as anti-television would prevail.

The Beginning: Point-to-Point

Technically speaking, television and Internet traffic were at first like oil and water: fundamentally unmixable. The Internet was envisioned as a "point-to-point" network,[4] meaning a system designed to facilitate communication between two nodes. Although some functionality in the Internet protocols allows the broadcast of data to all nearby nodes,[5] uses like broadcasting content to a large audience were never envisioned by the engineers who built the system. At the time, computers were not capable of receiving or displaying video at all.

In communication network design, the distinction between point-to-point and broadcast systems is one of the most basic. The metaphor used to explain the point-to-point Internet given by engineer and Internet pioneer Vint Cerf is that of the postal network, with packets of data functioning like postcards.[6] This is an apt metaphor that highlights the difference between broadcast and point-to-point. In over-the-air television broadcasting, a fundamental feature of the electromagnetic wave that radiates from a television station's transmission tower is that it makes no difference to the wireless signal whether it is received by one person or one hundred. Indeed, the cost of sending it—the cost of transmission—is the same in either case. Delivering television via satellite or via a cable network also employs a broadcast architecture and realizes the same benefit. In contrast, the costs of transmission for a postcard (and the Internet) scale linearly: in the case of one versus one hundred recipients, ninety-nine more postcards must be printed by the sender, and ninety-nine more postcards must be delivered by the mail carrier. Mail carriers must do ninety-nine times more work, but television antennas need change nothing. Ninety-nine more postcards require ninety-nine more stamps. In other words, unlike television broadcasting, the cost of transmission rises as the number of postcards transmitted increases.

The Internet could certainly have been designed differently,[7] but a postcard-like system conformed with the design goals of early Internet engineers. When I click on a link or type in a Web address to read a news story published by the *New York Times* at nytimes.com, a reasonable person might assume that the information comes from New York City, from a computer owned by the *New York Times*. The original vision of the Internet's design presumed as much. Information that some user wanted would be found where it had been produced, and the network's job was to facilitate a connection between one source and one recipient. This is partly because the point-to-point system linked relatively expensive, powerful, multipurpose computers that could act equally as senders and receivers—unlike the "dumb" televisions of the time that could only receive. All devices on the early ARPANET, the precursor network to the Internet, were expensive, multipurpose computers. In 2013 an Internet router cost about thirty dollars and was at least ten times cheaper than a computer. But on the ARPANET what is now called a router was a full-fledged computer in its own right. The first router, a Honeywell 516 microcomputer, was six feet tall and had four steel eyebolts in the top so that it could be transported by helicopter; it cost $100,000 in 1969[8]—$634,000 in 2013 dollars.

The users of this pre-Internet system (the ARPANET) were homogenous: they were largely computer scientists at elite educational institutions, and there were not many of them. At its launch in 1969 there were just four nodes on the network. Fifteen years later the network reached one thousand nodes. The foundations of the protocols we know as the Internet were crafted to serve a network of a few hundred computer experts using very capable, expensive machines. The largest, most successful, and largely unforeseen use for this system was a point-to-point application: email. (A 1973 report estimated 75 percent of the ARPANET's use was email.[9]) The Internet's designers envisioned using these machines to facilitate research file transfers, or, later, text-only email.

A postcard-like system for handling these communications was probably the most logical choice because it presented interesting technical problems in the context of computer networking research in the 1960s, and the ARPANET was a research network.[10] When it became clear that the ARPANET would become a network for non-academics, the envisioned users did not seem like people who would want "mass" communication. Personalization was assumed; users would all want different information. The early Internet was to be a network of equals, with the ideal user thought to be producing new knowledge, not passively receiving it. "Laudatory descriptions of the word 'active' in discussions of media use" have a long, gendered, and problematic history.[11] The Internet's pioneers were enthralled by what Nathan Ensmenger calls the myth of the "super-programmer"—a white-collar, well-paid male computer professional envisioned as an elite knowledge worker.[12] The users of the early Internet were thought to be "autonomous and creative,"[13] and the future network was depicted as serving elite men in universities and in industrial settings like IBM. In this future network, users would also be producers, content would be plentiful, and attention to it would be widely distributed.

Lick's Television: The Opposite of Television

When these ideas about the Internet were conceived, television could not have been more opposite. In the 1960s, television was a broadcast medium designed to distribute a show like *Gidget* or *Gilligan's Island* from one source (a television network like ABC or CBS) to as many receivers as possible. Television's one-way distribution network consisted of relatively unsophisticated nodes (television sets). In the 1960s the average U.S. television household received fewer than five channels, "cable" television referred to a cable that extended the range of an antenna, color television was new and not widespread, and "premium channels" did not exist. In the past, industry commentators often framed the rise of the Internet as a challenge to the network architecture and ideas of traditional telephone companies as the "netheads" versus "bellheads."[14] The canonical history of the Internet[15] does not mention the word "television" a single time. Despite that, it is this contrast of "television versus Internet" distribution that has come to define the media industries today, and it is this conflict that will ultimately come to transform both combatants.

What is at stake is not some arcane technical principle of point-to-point routing versus broadcasting, but the shape of culture itself. The Internet was the anti-television, and one of the pioneers of the Internet said as much in 1967. J. C. R. Licklider, a psychologist who headed the Information Processing Techniques Office at the Pentagon, is now credited with promoting a vision of computing that would become the Internet. Licklider, often known as "Lick," convinced the U.S. government to fund such a system and created interest among the engineers who would invent the means to make it possible. By one account, "most of the significant advances in computer technology . . . were simply extrapolations of Lick's vision . . . he was really the father of it all."[16]

Licklider's influential paper, "Man-Computer Symbiosis" (1960),[17] specified how interactive computing ought to work long before it was technically possible. Less attention has been given to his other visionary writing. In the late 1960s Licklider was invited to prepare a research paper for the Carnegie Commission on Educational Television, an influential nonprofit research and policy body whose proposals eventually led to a significant reorganization of television broadcasting in the United States and to the founding of the Corporation for Public Broadcasting. Licklider's research paper, "Televistas," did not receive wide attention.[18] In it he issued a stinging indictment of the existing technological system of television. He based his critique almost entirely on the system's distribution and transmission characteristics, writing,

> The great simplifying characteristics of conventional broadcast television are that it is broadcast and that the broadcast stations transmit to viewers who do not transmit back. . . . From an educator's point of view, the main intrinsic defects of broadcast television are that it offers everyone the same thing and does not give viewers a direct way of participating . . . [19]

Licklider went on to assert that what he called "selective television," which involved interactivity, would soon be possible via computer networks. In a dizzying feat of prediction, he forecast the end of "liveness" as a distinguishing feature of television and suggested that everyone would be able to select their own programs in near-real-time, watching them almost instantly. He foresaw a store-and-forward architecture for distributing video that is very similar to what is in use on the Internet today. He emphasized that "we are used to thinking of the output of a television set as ephemeral pictures,"[20] but that this would soon change, as television will be stored and manipulated as a data file: he called this "hard copy television."

For Lick the transmission architecture was a moral choice. His concerns were unabashedly paternalistic. He advocated for a television that would broaden access to a highly classed version of high culture, giving examples such as the symphony orchestra and community theater groups, as well as—somehow—fighting the war on poverty. He explained that this was "based on a philosophy that appreciates the interaction value of diversity among the personalities, interest patterns, of individuals as well as the cohesion value of community in language and cultural heritage—and a philosophy that prefers active participation to passive observation."[21] This was to be achieved by a global network of interconnected computers—what would become the Internet. In other words, in 1967 Licklider offered the Internet as a salvo aimed at the heart of television—its network architecture. Combat was joined, but from today's vantage point it appears to be television's distribution and transmission system that will prevail.

The Challenge of Asymmetry

Licklider's emphasis on selectivity and knowledge production promoted a future in which different users wanted different things—discussed today as the Internet's "long tail."[22] While this was an attractive story for many commentators, it often did not fit the pattern of how users actually behaved on the Internet, causing a variety of problems well before the advent of online video. When Sir Tim Berners-Lee invented the World Wide Web in 1991, like the ARPANET, it was framed as a tool for a select group of highly educated knowledge workers who would produce as much as they consumed.[23] The Web's original blueprint included the feature that any Web user could edit any Web page,[24] which now seems quite impractical. Early Web clients were referred to not as a "Web browser" but as a "browser/editor." So were all computers created equal.

Returning to the *New York Times* example, Lick's vision of the Internet and Berners-Lee's vision for the Web meant that a computer at the *New York Times* headquarters building would hold the news stories as Web pages to be disseminated, and when a user wanted one, he or she would query it (for example, from Ann Arbor, Michigan). The network's logic presumed that the same linkage might occur in reverse. The New York City computer would then potentially be used by the reporters there to query a computer in Michigan for some Web pages of value to the *Times*. In this hypothetical example, when we try to think of what kinds of Web pages an average user might write that a *Times* reporter might need, imagination fails. In fact, far more people are able to read good articles than to write them. So are media producers and audiences created unequal.

This asymmetry created serious problems when the Internet began "mass" communication—distributing the same thing to a large number of people. In a point-to-point system each communication is a separate transaction (recall, just like a postcard). A Web *server* is a machine, online all the time, that waits for a request to see one of the Web pages stored on its hard disk (so that it can *serve* them like a waiter at a restaurant, hence the name "server"). At small numbers of requests per minute, the number of people requesting a Web page from the server does not matter. But at some point, as traffic increases, the Web server or the network near the server becomes overwhelmed. Either there is not enough processing capacity to make a new copy of the requested Web page for every user who demands it (called "server load"), or there is not enough available network capacity near the server to deliver copies of those pages ("source congestion"). Remember that unlike traditional over-the-air television broadcasting, a new transaction must be made for each request.

This problem is common enough that a new phrase was coined to describe it: "the Slashdot Effect."[25] It is named after a popular 1997 technology news service on the Web called Slashdot. Slashdot invited users to submit their own links to interesting websites.[26] When a Slashdot user found a juicy Web page and shared the prize address, however, the clicks of Slashdot readers would generate requests that would overwhelm the target Web server. The act of promoting content to even Slashdot's modest audience sometimes caused that content to become instantly inaccessible due to server load or source congestion: the Slashdot Effect. Although it was named after this niche Internet service, the "Slashdot Effect" became a generic term; a large-enough massing of attention on the Internet focused on any single website would bring it down.

Television has been explained as unique in that it is a system that can be used by the establishment or "the center" of society to command public attention for a communal event.[27] It is a technology defined by the experience of millions of people all watching the same thing at the same time. But on the Internet produced by Lick's vision, such a pattern of communication was impossible. The Slashdot Effect would cause the server to crash or the network to collapse. The Internet has often been characterized as inherently amenable to decentralized communication, lateral connections, bottom-up user power, and user-generated content. Nevertheless, many commercial parties did not take limits like the Slashdot Effect as features inherent to the medium but as technical and commercial obstacles that could with effort and investment be overcome. Internet engineers asked: Since Internet audiences had demonstrated a desire to look at the same content at almost the same time, how can the Internet be redesigned to support that desire? At the same time, media companies and start-ups asked: Who will be the provider of this content that everyone wants to watch? Lick's network had challenged television with a new distribution architecture, and television rose to respond.

Retrofitting the Internet: Streaming, Multicast, and IPTV

Even before video was a major source of Internet traffic, as mainstream media sources migrated to the Web they desired large audiences and therefore asymmetric communication patterns. They sought a solution to the Slashdot Effect. At first, providers handled the problems of load and congestion by simply buying larger Web servers and more network capacity. Some mainstream media sources moved their Web servers into data centers operated by the largest and most interconnected Internet Service Providers (a practice called colocation), gaining the interconnection advantages of a central network location. Multiple identical servers were grouped together, and traffic was balanced between them, a practice called server farming. However, very popular content continued to produce "congestion events" that crippled service. For instance, during the previous decade in the United States, peak congestion events involving a high demand for video included the 9/11 attacks, the inauguration of Barack Obama, and Michael Jackson's funeral. Building a very expensive and robust network to handle rare, peak-load congestion events was not economical (this problem is common to many kinds of networked infrastructure[28]). In addition, as online multimedia shifted from audio to video, the larger file sizes of video exacerbated the problem.

Providing popular audiovisual content on the Internet had quickly come to look more like a factory enterprise from the Industrial Revolution than the postindustrial future that had been promised. Large investments in Web servers and IT staff, as well as giant, power-hungry data centers involving large capital investments, had all become a necessary part of publishing popular content on the Internet. The warehouse-sized printing machinery that pressed out each copy of a daily newspaper was being replaced by warehouse-sized computing machinery that pressed out and sent each batch of electrons—an instance of a Web page or video stream. Bits were substituted for ink and paper, yet the result was no less industrial in scale. Even when throwing money at the problem, the strategy of simply buying more and better servers did not seem to be working. The issue was more fundamental. Lick's network was built with the assumption that content was plentiful, and his network "appreciates the . . . value of diversity" in cultural products, but millions of users were demanding multiple copies of the same thing, and something would have to be done about it.[29]

A longer-term fix would be to undo Lick's vision, rewriting the basic protocols of the Internet itself. New protocol proposals aimed to make the network more amenable to one-to-many video. Sometimes termed IPTV (for Internet Protocol TeleVision), this solution was in the works but proceeded very slowly in the Internet's plodding technical standardization bodies.[30] Experimental efforts in Internet engineering also sought to build a new facility into the network, available to anyone, called "multicast."[31] Multicast (another computing term) is a hybrid architecture somewhere between point-to-point and broadcast in which the same item of content is distributed to a list of many recipients. Ideally, multicast would not result in the "postcard problem" of many duplicated requests to fulfill: if implemented as its designers hoped, nodes near each other would "subscribe" to a multicast, sharing the same "postcard" (that is, copy of the content) without generating a new request for every single recipient. This meant that the point-to-point Internet could acquire some of the characteristics of broadcasting—some transmission costs that would not increase as the number of receivers increases. However, in trials multicast techniques did not scale well with large audience sizes.

Other, more successful efforts addressed the way data flowed through the distribution network. "Streaming," in computer terms, is the display of media while they are still being received. Streaming was the norm for television—so much so that the word did not need to be coined—but it was a novelty in computing. During the 1980s and early 1990s personal computers and networks were not powerful enough to stream media—that is, it is unlikely they could receive or decode a stream of incoming data fast enough to simultaneously render it for the user. As computers and networks became more powerful, streaming became viable and pioneers like Progressive Networks (later known as RealNetworks) wrote new software and protocols like RealAudio to allow multimedia streaming. The first live event to be streamed over the Internet was the audio coverage of a baseball game between the Seattle Mariners and the New York Yankees in 1995, streamed by a RealAudio server.[32]

Streaming technology was useful because it improved the responsiveness of the Web for viewers of multimedia—no longer would they have to download an entire file before playing it. At the same time, it later offered advantages to the Web's distribution system. By determining the user's network speed, streaming software could decree that only a particular amount of data would be sent in advance of the user's need for it: this is known as the buffer. In online video distribution today, for instance, the maximum buffer size is often limited. Only a few seconds of video are sent to the user ahead of what they are currently watching. As most users watch only the first few seconds of most online videos, the rest of the video data are never sent, saving substantial network capacity.

A variety of ancillary technologies were also developed that made watching video over the Internet more tractable. Improvements in video compression resulted in new formats (such as MPEG video standards) that reduced the size of video files. Adaptive bitrate streaming, in another example, is a technique wherein a sender encodes a video at a variety of different quality levels. Poor picture quality produces smaller file sizes and thus fewer bits to transfer. In an adaptive bitrate scheme, software on the viewer's computer senses the quality of the network connection and acts as a switch directing the server to send a lower-quality version of the requested content when the network is busy, conserving network capacity. Or, to put it in the words of one user: "Netflix quality all of a sudden terrible" [sic].[33] These significant innovations in streaming and compression transformed the Internet and made it possible to reliably watch television content at all. However, the most significant change in online video distribution came with the emergence of a new kind of distribution network.

Re-Architecting the Mass Audience: Edge Caching and Upload Limits

As the Internet evolved, a remaining technical challenge was adapting its point-to-point architecture to the one-to-many asymmetries of audiences and attention. A commercial breakthrough came when an MIT applied mathematics professor created the spin-off company Akamai.[34] Rather than wait for Internet protocols to change or use custom client software (like RealNetworks), Akamai cleverly took advantage of the Internet's addressing system. The Akamai network detects where a video request originates—both in geographic and network topographic terms—and then invisibly directs that request to a server that is as close to the request as possible.[35] Unlike a public standard built into the protocols of the Internet, Akamai is a proprietary system that acts as an overlay, an invisible network concealed inside the network.[36]

This is an example of a "cache"—in computing this term means the same as it does in children's stories about pirates. A cache of pirate treasure is a place where gold has been left temporarily so that it can be picked up later. Akamai's strategy, called "edge caching," moves content away from the producers and stores it close to the consumers, reducing network load and transmission delays. This is conceptually similar to the television distribution strategy of stocking libraries of videotapes at television affiliates for local broadcast, or a local television affiliate taping a network feed, then rebroadcasting it later. For Akamai's edge caching to work, however, it would have to operate a gigantic network of data centers all over the world, putting its own servers as close to valuable audiences as possible.

Although the company has zero name recognition among Internet users, in a little more than a decade Akamai was running the largest number of Web servers of any entity in the world, with servers in eighty-seven countries, connecting nineteen hundred distinct Internet subnetworks.[37] While companies like Microsoft, Facebook, and Google probably operate more servers—their total numbers are not known—the computers at those companies also do more than act as Web servers or as a distribution system for others' content. Yahoo! was Akamai's first major customer, and other customers that followed have included Apple, Google, Disney, ESPN, and Viacom. Up to 30 percent of all Internet traffic ran across Akamai's distribution network in 2013,[38] serving more than 50 percent of the Internet's top one thousand websites by traffic volume.[39] Those large media and Internet companies that do not use Akamai likely have gone into the distribution business themselves to reduce costs, building their own network of edge caches around their most valuable audiences. Akamai's edge cache overlay technique pioneered a market that would later come to be called "content delivery networks" or sometimes "content distribution networks" (CDNs). The top three CDNs in 2013 market share were, in order, Akamai, Amazon, and Edgecast (the latter owned by telecom giant Verizon).

The operation of these hidden (to users) edge-caching distribution networks can produce surprising consequences. If a video source pays for CDN distribution, Web pages and videos will load faster and may play at a higher quality. CDN-hosted videos are less likely to be interrupted, and they are less likely to change resolution while playing. Some CDNs also offered tiered service, allowing their clients to pay more for better service. To the viewer who is not aware of the distribution infrastructure, the experience of "flow"[40] when viewing online video is quite puzzling. Discussion boards are filled with varieties of the same question: "Why do ads always load flawlessly, while other video is choppy and slow-loading?" (The answer could be a CDN.) Or, "Why do some videos look terrible on a fast Internet connection?" (No CDN.) Internet audiences have no way to know why the quality of some videos is worse than others. They are likely to wrongly blame their Internet service provider rather than to realize that their attention is less valuable than someone else's and that a producer declined to pay to make this video load faster for them.

The marketing literature for CDNs claims that a video producer subscribing to a CDN will see a 60 percent to 99 percent reduction in the network bandwidth they use (users now query the CDN, not the source). CDNs promise responsiveness that is seven times faster (or greater) than content from nonsubscribers. CDNs are also facilitating a new kind of performance-based differentiation in Web content. Even though Web pages themselves continuously become larger and more complex, CDNs now measure average response times in milliseconds and are aware that the online audience can be trained to differentiate these load times and to desire a particular user experience: they can be trained to notice and appreciate CDNs without knowing that they exist. These are the kinds of production values that have long been used by well-financed players for competitive advantage in the media industries.[41]

In a more worrying vein, until Amazon entered the CDN market with its CloudFront offering in 2008, the best CDNs (including Akamai) refused customers not affiliated with major corporate content producers.[42] Although this echoes the "corporate liberalism" of earlier U.S. broadcast policy, which restricted the television medium to major producers,[43] in this case the motive was probably that of a wholesaler (the large CDNs) uninterested in the retail trade. Until Amazon's entry, smaller, independent media producers could not benefit from a CDN at all. (Today they can subscribe to Amazon's CloudFront CDN if they can afford it.[44])

This orientation away from symmetry between users and producers later filtered down into the technologies of broadband Internet service, where it has crystallized. In 2014, wired broadband Internet across the world is provided via DSL (digital subscriber line) attached to a copper telephone network, cable modems attached to a coaxial cable television network, or a new optical-fiber network.[45] Early DSL and fiber protocols originally assumed that each user would transmit as much as he or she received. Nonetheless, by 2014 DSL protocols typically assume that the user will receive about twenty times more information than he or she transmits, cable networks assume that the user will receive three to five times more, and fiber networks assume the user will receive ten times more. Any Internet user can take an online speed test (at http://speedtest.net, for example) to reveal the decisions their Internet service provider has made about how much they may consume or produce—often labeled "downstream" versus "upstream" capacity.

When compared to the extremely constrained world of 1960s television, the Internet of 2015 must seem emancipatory: everyone has access to many more than five channels. Some forms of computer-mediated interactivity and participation are now possible, yet these are more limited than Lick had hoped. It is clear that this emerging distribution infrastructure is now strongly shaping the experience of video and the future Internet. Lick is widely acknowledged as a visionary, and it could be said that these days Lick's vision of "man-computer symbiosis" is being slowly replaced by his vision of "selective television." Yet Lick hoped that the computer-enabled television of the future would not provide everyone with access to "the same thing" and this is where Internet video departs from his aspirations for interactivity and community media production. While Lick's notion of an active audience of users producing their own media is not dead, it has been merged with the desires of traditional one-to-many broadcasters to form an interesting new technological hybrid. To produce this hybrid the Internet has often been willfully bent to train an interactive, peer-to-peer system toward the older commercial vision of "mass communication."

Certainly the Internet was originally thought to promise widespread "demassification" or "disintermediation"—anyone could be a publisher or a broadcaster with these new systems.[46] Most recent commentators on the evolution of television emphasize the significance of amateur self-publishing, noting that the Internet represents "a revolution in distribution that exponentially increases the ease of sharing video."[47] The implications of the Internet's distribution architecture are not yet clear, but they do not seem to fulfill these earlier visions and potentials. Instead, today they provide a complex, tiered system firmly biased toward large and well-capitalized media producers who have access to special networks (CDNs) and dedicated downstream bandwidth. Today it is possible to stream the Super Bowl online and post status updates to Facebook about it. We can watch *Gilligan's Island* online at a time we choose, and we can tweet about it. Nonetheless, this does not feel like the revolution Lick called for. If anything, the role of computation in today's implementation of Lick's "selective television" has been to optimize the selection of people for advertisements, not content for audiences.

The Internet Medium, Revised and Reconsidered

One important lesson from this story is that the Internet is now far from the point-to-point system of equals planned decades ago. Commentators expected that providing television via the Internet would transform television, but instead it caused the Internet's distribution architecture to become like television in significant ways. In the words of *New York Times* television critic Brian Stelter, "The Internet, which was thought to be a TV killer, is turning out to be its wingman."[48] Recent empirical studies of Internet traffic have pushed this point further, revealing that the network has reached an inflection point, where the Internet is now, for the first time, centrally organized around serving video. And this does not refer to video as a mode of communication in general, but specifically to serving a particular kind of video from a very small number of providers to large numbers of consumers.[49] The Internet is now television, or it will be soon. During peak video watching times, two providers (Netflix and YouTube) account for more than half of all Internet traffic in North America.[50] Consumer video accounted for 57 percent of all Internet data in 2013, not including peer-to-peer traffic.[51] A recent study found that at peak television viewing hours 34 percent of North American wired broadband traffic went to just one source—Netflix.[52] In another account, up to 80 percent of all network traffic during peak viewing times on one wired commercial Internet service provider went to Netflix.[53] These are not simply statistics about user preferences for video over other kinds of activity: remember that without the strenuous technological revisions to the Internet's distribution architecture described earlier, Netflix and YouTube streaming would not be possible at all.

Reflecting on the general narrative of Internet video's development, it is clear that media infrastructures do not have the essential characteristics that are often attributed to them. Just as the Internet is often thought to be "about" the long tail or user-generated content, television is often thought to be "about" liveness.[54] Jonathan Sterne countered that "the very possibilities for the experience of live television" were strongly shaped by the evolution of television's distribution infrastructure.[55] A national television distribution network was willfully called into existence in the United States before 1962 by corporate executives who were convinced that the key to profitability for the medium was advertising to a national audience. This implied that the nation must be able to watch the same television at the same time, and so AT&T was asked to construct a television rebroadcast infrastructure atop the national common carrier telephone network. Just as this chapter explained the attempts to surmount the technical challenges in distributing video over the Internet, U.S. television networks confronted the technical challenges of distributing television signals over long distances by investing in research on microwave relays and coaxial cable.

Beginning in the 1960s, engineers believed in Lick's vision, and they constructed the Internet to be the anti-television he proposed. They designed it for the people they imagined themselves to be, the reflexive users, eager to appreciate a symphony or to play in one—and not to lounge around the living room passively watching *Days of Our Lives*.[56] Even so, as the network grew and attracted the interest of commercial firms, capital eyed the Internet as a new route to profit via arbitrage. The Internet, as a new communications medium, could be a chance to displace the profitable video distribution bottlenecks of the twentieth century. Yet simply using the Internet to distribute television would not work. At first, video distribution was technologically impossible, and later the Internet's distribution infrastructure thwarted commercial attempts to develop a one-to-many video audience for almost two decades.[57] Money, resources, and ingenuity were thrown at the problem. Attempts at a solution proceeded on a dizzying number of fronts: compression, streaming, buffering, colocation, bandwidth, server farms, data centers, and others. It finally took changes to standards, protocols, and system architectures to denature the assumptions of Lick's point-to-point networking in favor of the more familiar model of mass communication as exemplified by the CDN. While the existing system is a hybrid, the direction of change has been toward a mass audience.

The key implications of this story relate to the form of content itself and the shape of our shared culture. In the United States "television" has been thought of as a container for television-specific content: a notional box that, when you look inside it, contains entertainment. The Internet is thought of as something quite distinct—a notional box that should contain something else, something different. Lick thought the box should contain symphonies and the grassroots content that users produce. Indeed, as time passed, it started to seem that his idea had prevailed. As one meme put it, the Internet is full of cats.[58] (It was a medium essentially "about" quirky, user-generated content.) To ask again a central question of media theory and a preoccupation of the Toronto School[59]—How does the container affect the form of the content it can contain?

The medium of the Internet has transformed over the last forty years from a textual system to an audiovisual one, shifting from a network of text-only emails to YouTube videos. The transformation was intentional, and not a process of maturation explained by computers and networks naturally becoming faster. Television was not just poured into the Internet box. Instead, engineers and venture capitalists worked to change the medium itself and optimize it for mass communication, providing a way to assemble large audiences for relatively few sources. These interventionists were radicals and upstarts in that they were not working for old television companies, but they were conservative in that they found that the Internet's new architecture and distribution system could not provide the older form of mass television, so they sought to revise it by looking backward for inspiration. While there was a logic at work of meeting consumer demand and satisfying customer taste, there was also a sense that the Internet user could be taught what to want, and that wanting user-produced material without commercials was not profitable. As the medium of the Internet continues to transform, it appears to be moving further from the participatory goals held by Lick and many commentators,[60] raising the question of what our normative position on access to the means of distribution should be.

Transforming the Internet medium to make television fit inside it did not simply add capabilities, making mass broadcasting easier. As the medium changed, older Internet patterns of point-to-point or peer communication were made more difficult. Today, Internet users are prohibited by their subscriber agreements from running their own servers. If a user tries anyway and becomes popular, their networking hardware no longer supports the many-to-many pattern of traffic flows that personal servers would require. Without access to a CDN, content from a mainstream, well-capitalized media company would load perceptibly faster than what the user offered, and thanks to distribution investments, traditional television content might even be seen at a higher resolution. In sum, the distribution infrastructure of the Internet has changed to make some content distribution easier and some more difficult. While user participation has not been eliminated, interactivity has been constrained to actions that surround and amplify content provided by mainstream media companies. Some of these companies, such as Netflix, are Internet upstarts, but they share strategies and technologies with mainstream media projects like Hulu (owned by NBCUniversal Television Group [Comcast], Fox Broadcasting Company, and the Disney-ABC Television Group). These video streams are not nearly the departure from *Gidget* that other writers once foresaw. The Internet is being "re-massified," but this battle is not over. Those who see a vibrant point-to-point future of videoconferencing and interactive gaming may hope to retrofit the infrastructure once again.

Distribution as Diagnostic, Distribution as Destiny

As this chapter has revealed, Internet architecture is important, but it is neither fixed nor inevitable. Internet engineers, for instance, once discussed the trade-offs between solving the problems of video distribution via a private, proprietary, invisible CDN (accessible to only those providers who pay for it) and providing such facilities in public by modifying the basic protocols of the Internet itself (making these features accessible to anyone).[61] A final assessment concerns the implication of these facts with regard to how we think about all media systems. Investments in infrastructure make earlier decisions durable and difficult to change, but ultimately these systems are built by people and can be rebuilt by them. As a result, distribution architecture remains an important site of investigation for the media scholar, as well as an avenue for intervention by the media activist.

To the media scholar these characteristics of online video are likely amazing: most studies of online video proceed wholly from the perspective of either the user or the content, making the details above inaccessible. Those researchers who do consider another view often focus on industrial history or political economy, but some of these perspectives neglect either the technology or the distribution network. Studies focusing on technology, for instance, tend to focus on new developments in the apparatus in the home, ignoring the pipes and wires that lead there. Much more could be learned with the distribution infrastructure in the center of our view, echoing Sterne's calls for future analyses of the "mode of distribution" rather than production or reception.[62] In this case, telling the story of Internet video without the above focus on distribution could wrongly make it seem that the development of online video was purely a matter of user preference. A future analyst might one day wrongly conclude that the story was: "For a while, early Internet users made and watched their own videos about cats, but then they wanted to watch mainstream media offerings like *Modern Family*." In fact, reorienting the Internet audience toward mass offerings has been a coevolution of taste, massive infrastructural investments, and important technological achievements.

On final reflection, such a focus on the normally invisible infrastructures of distribution is not completely rare.[63] When the satellite emerged as a viable technology for video distribution in the late 1960s, the transmission and distribution architecture loomed large enough to capture the attention of media analysts of all stripes. Satellites were evocative, engendering what Lisa Parks has called the Western fantasy of "global presence."[64] But they also seemed to offer a reorganization of television based on transmission. Satellite signals were naturally able to leap national borders (significant during the Cold War). Satellites also incorporated the potential for disintermediation: they could be used to establish a direct link between a source in one part of the world and a receiver in another, bypassing any local distribution networks.

Within the distribution infrastructure lies a clear picture of which speakers are valued and what content is important. The distribution infrastructure is a crucial battleground: competing visions of society are made manifest within seemingly technical struggles, yet they are also modified by the inertia of technology. Led by Herbert I. Schiller, the early critical analysis of satellites was more than an examination of the technology or political economy of a technology itself, it was a strategy for scholarly inquiry into media that focused on transmission as a critical step in the media system and the circulation of our culture.[65] To Schiller, transmission was crucially diagnostic, as it could reorganize who could speak. He emphasized over and over that communication "is dependent ultimately on some form of transmission,"[66] and that the working definition of the media and communications industries "includes data generation and transmission."[67] He wrote, "The transmission structures that are being established nationally and internationally provide . . . evidence of the character of the systems emerging in the Information Age."[68] Lick would surely have agreed.

Notes

1. For one YouTube version of this prank, see: https://www.youtube.com/watch?v=Cjbry-mObCo.

2. Susan Leigh Star, "The Ethnography of Infrastructure." *American Behavioral Scientist* 43 (1999): 377–91.

3. For an overview, see Christian Sandvig, "The Internet as Infrastructure," in *The Oxford Handbook of Internet Studies*, ed. W. Dutton (Oxford: Oxford University Press, 1999), 86–108.

4. Janet Abbate, *Inventing the Internet* (Cambridge, Mass.: MIT Press, 2000).

5. This was intended for the purpose of sharing routing and control information, not content. See J. Mogul, "Broadcasting Internet Datagrams," *IETF Network Working Group Request for Comments (RFC)*, October 1984, 919, available at http://tools.ietf.org/html/rfc919 (accessed September 20, 2014).

6. See, for example, http://www.bbc.co.uk/blogs/digitalrevolution/2009/11/rushes-sequences-vint-cerf-int.shtml (accessed September 20, 2014).

7. Laura DeNardis, *Protocol Politics: The Globalization of Internet Governance* (Cambridge, Mass.: MIT Press, 2009).

8. Allen Kent and James G. Williams, eds., *Encyclopedia of Microcomputers v. 17: Strategies in the Microprocess Industry to TCP/IP Internetworking: Concepts: Architecture: Protocols, and Tools* (New York: CRC, 1995).

9. Stepthen Segaller, *Nerds 2.0.1: A Brief History of the Internet* (New York: TV Books, 1999), 110.

10. Abbate, *Inventing the Internet*.

11. Ellen Seiter, *Television and New Media Audiences* (Oxford: Oxford University Press, 1999), 130; see also Lisa Parks, "Flexible Microcasting: Gender, Generation, and Television-Internet Convergence," in *Television after TV: Essays on a Medium in Transition*, ed. Lynn Spigel and Jan Olsson (Durham, N.C.: Duke University Press, 2004), 133–62, 138.

12. Nathan Ensmenger, *The Computer Boys Take Over: Computers, Programmers, and the Politics of Technical Expertise* (Cambridge, Mass.: MIT Press, 2012).

13. Thierry Bardini, *Bootstrapping: Douglas Engelbart, Coevolution, and the Origins of Personal Computing* (Stanford, Calif.: Stanford University Press, 2000), 108.

14. Steve G. Steinberg, "Netheads vs. Bellheads," *Wired 4.10*, October 1996.

15. Abbate, *Inventing the Internet*; Steinberg, "Netheads vs. Bellheads."

16. Bob Taylor, quoted in M. M. Waldrop, *The Dream Machine: J. C. R. Licklider and the Revolution That Made Computing Personal* (New York: Viking, 2001), 470.

17. J. C. R. Licklider, "Man-Computer Symbiosis," *IRE Transactions on Human Factors in Electronics HFE-1* (1960), 4–11.

18. It may have been ignored because he turned it in late. See the note at the bottom of the 1967 Carnegie Report, 113.

19. J. C. R. Licklider, "Televistas," in *Public Television: A Program for Action*, ed. Carnegie Commission on Educational Television (New York: Harper & Row, 1967), 201–25, 202.

20. Ibid., 209.

21. Ibid., 214–15.

22. Chris Anderson, "The Long Tail," *Wired*, October 2004, available at http://archive.wired.com/wired/archive/12.10/tail.html (accessed September 20, 2014).

23. Tim Berners-Lee, *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web, by Its Inventor* (New York: HarperCollins, 2000).

24. Ibid., 27, 29, 42.

25. See, for example, the entry in the Jargon File: http://catb.org/jargon/html/S/slashdot-effect.html.

26. Anita Chan, "Slashdot.org" in *The Inner History of Devices*, ed. Sherry Turkle (Cambridge, Mass.: MIT Press, 2008), 125–37.

27. Daniel Dayan and Elihu Katz, *Media Events: The Live Broadcasting of History* (Cambridge, Mass.: Harvard University Press, 1994), 4.

28. For example, see Thomas Parke Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore, Md.: Johns Hopkins University Press, 1993).

29. Licklider, "Televistas," 215.

30. DeNardis, *Protocol Politics*.

31. Stephen E. Deering, "Host Extensions for IP Multicasting," *IETF Network Working Group Request for Comments (RFC) 1112* (1989), available at http://tools.ietf.org/html/rfc1112.txt (accessed September 20, 2014).

32. Geert Lovink, *Dynamics of Critical Internet Culture: 1994–2001* (Amsterdam: Institute of Networked Cultures, 2002), 164.

33. There are many accounts of this experience online. This example is from http://community.sony.com/t5/Blu-Ray-Netflix-Online-Video/Netflix-quality-all-of-a-sudden-terrible/td-p/24363 (accessed September 20, 2014).

34. "MIT Scientists Develop New Method to Distribute Content over World Wide Web," Akamai, 1999, available at http://www.akamai.com/html/about/press/releases/1999/press_011499.html (accessed September 20, 2014).

35. J. Dilley, B. Maggs, J. Parikh, H. Prokop, R. Sitaraman, and B. Weihl, "Globally Distributed Content Delivery," IEEE Internet Computing (September/October 2002): 50–58.

36. K. Andreev, B. M. Maggs, A. Meyerson, and R. K. Sitaraman, "Designing Overlay Multicast Networks for Streaming," *Proceedings of the Fifteenth Annual ACM Symposium on Parallel Algorithms and Architectures* (SPAA), San Diego, California (2003), available at http://www.akamai.com/dl/technical_publications/DesignOverlayMulticastnewtworksforStreaming.pdf (accessed September 20, 2014).

37. Rich Miller, "Akamai Now Running 105,000 Servers," *Data Center Knowledge*, Mar. 8, 2012, available at http://www.datacenterknowledge.com/archives/2012/03/08/akamai-now-running-105000-servers (accessed September 20, 2014); Alexander Eule, "The WD-40 of the Internet," *Barrons*, February 1, 2014, available at http://online.barrons.com/article/SB50001424053111903911904579346821089194680.html?mod=googlenews_barrons (accessed September 20, 2014).

38. Eule, "WD-40 of the Internet."

39. "CDN Market Share Update December 2013" *Datanyze*, December 2013, available at http://www.datanyze.com/blog/cdn-market-update-dec-13 (accessed September 20, 2014).

40. Raymond Williams, *Television: Technology and Cultural Form* (New York: Routledge, 2003).

41. For example, https://blogs.akamai.com/2012/09/web-performance-why-one-size-doesnt-fit-all.html (accessed September 20, 2014).

42. Christian Sandvig, "The Structural Problems of the Internet for Cultural Policy" in *Critical Cyberculture Studies*, ed. D. Silver and A. Massanari (New York: New York University Press, 2006), 107–18.

43. Thomas Streeter, *Selling the Air: A Critique of the Policy of Commercial Broadcasting in the United States* (Chicago: University of Chicago Press, 1996).

44. There are also exciting new developments in CDNs, including research promising that cooperative, free CDNs might be assembled from large groups of users without a data-center infrastructure, and the advent of one CDN that offers free service to anyone (CloudFlare). It is not yet clear how these developments will unfold.

45. Or some combination of the three—for example, "FTTx."

46. Rob Kling, "Being Read in Cyberspace: Boutique and Mass Media Markets, Intermediation, and the Costs of On-line Services," *Communication Review* 1, no. 3 (1996): 297–314.

47. Amanda Lotz, *The Television Will Be Revolutionized* (New York: New York University Press, 2007), 16.

48. David Carr, "Talking Back to Your TV, Incessantly," *New York Times*, March 14, 2010, available at http://www.nytimes.com/2010/03/15/business/media/15carr.html (accessed September 20, 2014).

49. C. Labovitz, S. Lekel-Johnson, D. McPherson, J. Oberheide, and F. Jahanian, "Internet Inter-Domain Traffic" in *Proceedings of the ACM Special Interest Group on Data Communication*, SIGCOMM (2010), 79–86, 85.

50. "Global Internet Phenomena Report: 2H 2013," *Sandvine*, 2013, available at https://www.sandvine.com/downloads/general/global-internet-phenomena/2013/2h-2013-global-internet-phenomena-report.pdf (accessed September 20, 2014).

51. "Cisco Visual Networking Index: Forecast and Methodology: 2012–2017," Cisco, 2013, available at http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360.pdf (accessed September 20, 2014).

52. Todd Spangler, "Netflix Remains King of Bandwidth Usage, While YouTube Declines," *Variety*, May 14, 2014, available at http://variety.com/2014/digital/news/netflix-youtube-bandwidth-usage-1201179643 (accessed September 20, 2014).

53. This statistic comes from a personal communication with a network operator who asked not to be named.

54. For a conceptual review of what "liveness" entails, see Paddy Scannell, *Television and the Meaning of "Live": An Enquiry into the Human Situation*. (New York: Polity, 2014).

55. Jonathan Sterne, "Television Under Construction: American Television and the Problem of Distribution 1926–1962." *Media, Culture and Society* 21, no. 3 (July 1999): 503–30.

56. The phrase "reflexive users" comes from Thierry Bardini.

57. The idea of a technology "resisting" attempts to manipulate it is taken from Bruno Latour, "When Things Strike Back: A Possible Contribution of 'Science Studies' to the Social Sciences," *British Journal of Sociology* 51, no. 1: 105–23.

58. Joel Veitch, "The Internet is Made of Cats." *Rathergood.com*, January 14, 2010, available at http://www.rathergood.com/cats (accessed September 20, 2014).

59. James W. Carey. "Harold Adams Innis and Marshall McLuhan," *Antioch Review* 27, no. 1 (1967): 5–39.

60. Henry Jenkins. *Convergence Culture: Where Old and New Media Collide* (New York: New York University Press, 2006).

61. See Sandvig, "Structural Problems."

62. Sterne, "Television Under Construction."

63. See also Nicole Starosielski, "'Warning: Do Not Dig': Negotiating the Visibility of Critical Infrastructures," *Journal of Visual Culture* 11, no. 1 (2012): 38–57.

64. Lisa Parks, *Cultures in Orbit: Satellites and the Televisual* (Durham, N.C.: Duke University Press, 2005), 23.

65. Herbert Schiller, "Computer Systems: Power for Whom and for What?" *Journal of Communication* 28, no. 4 (1978): 184–93.

66. Ibid., 190.

67. Ibid., 185.

68. Ibid., 190.