Timothy Goodwin
Digital Media Final Paper
May 8th, 2017

Pipes that Empower: Assessing the Cultural and Environmental Impacts of Online Streaming

Video currently accounts for 70% of all internet traffic and has been projected to hit 90% by 2020.[1] Its growth has been rapid — in 2006 video made up only 12% of all traffic, but by 2010 it was already the largest Internet traffic category. The principal reason behind this expansion is that viewing online video simply was not a good online experience before the mid 2000s. Today, network technology has evolved such that viewers can watch videos, even in high definition, without the buffering or graininess that formerly plagued the playback experience. At the center of the online video explosion is Netflix, which currently accounts for 40% of peak-time internet traffic in North America on any given day.[2] Netflix's ascension from a DVD-by-mail service to an online media giant has been a remarkable process, having endured altercations with both the entertainment industry and the telecom industry. A critical part of Netflix's ascension, however, was the company's decision to invest heavily in their network infrastructure. Since their streaming service launched in 2007, the company has been on a mission to eliminate the video playback problems of the mid-aughts. This mission culminated in 2012 with the announcement of Netflix Open Connect, a billion-dollar investment in proprietary network infrastructure to provide its subscribers with a consistent and high-quality streaming experience. "Binge watching" and the culture surrounding Netflix's streaming paradigm are ultimately upheld by these investments in network technology. By investigating the infrastructures behind a Netflix user's video stream, this paper seeks to

[1] "Cisco Visual Networking Index: Forecast and Methodology, 2008–2013," Cisco Inc, 2009.
[2] Wong, Joon Ian. "The Internet Has Been Quietly Rewired, and Video Is the Reason Why."*Quartz*. Quartz, 05 Oct. 2016. Web. 08 May 2017.

explore a relationship between advancing network technologies and the a sovereignty of the Internet-era media consumer, as well as the consequences specific to this relationship.

Netflix has worked persistently to bring a quality streaming experience to its customers as its subscriber base has expanded. These efforts included cross-industry clashing with ISPs who were unhappy with the disproportionate amount of traffic Netflix's service was adding to their networks. Instead of coming to some mutual agreement over these net neutrality debates, Netflix opted to build out their own content delivery network (CDN), a project the company calls Netflix Open Connect. Open Connect is a network of servers that hold copies of the Netflix library at various storage locations around the world. This content delivery network positions content at the network "edge" such that a video can be streamed to a customer from the closest Netflix server, enabling the stream data to bypass the busy Internet "core" and thus reducing buffering for the end user. To build out the Open Connect network, Netflix developed the Open Connect Appliance. The OCA, essentially a rack-mounted box full of high capacity hard drives, is a custom built server designed to stream terabytes of video a day. The company partnered with regional ISPs in nearly a thousand separate locations to install these OCAs at internet interconnection locations and regional ISP data centers. Today, Open Connect delivers 100% of the company's video traffic.[3] So, to revisit the astonishing statistic that Netflix accounts for 40% of peak-time internet traffic, this scenario actually resembles a few hundred of these OCAs distributed across North America streaming video to nearby customers, rather than 40% of the internet backbone links being consumed by Netflix.

This peak-time statistic holds an interesting parallel to the "prime time" of conventional television programming: many viewers "tuning in" at the same time, albeit in entirely separate, private places. Yet, the infrastructural requirements of the Netflix's "prime time" are on an

[3] "How Netflix Works With ISPs Around the Globe to Deliver a Great Viewing Experience." *Netflix Media Center*. N.p., 17 Mar. 2016. Web. 08 May 2017.

entirely different order of magnitude. Broadcast media, like television, only require a device to "tune in" to a pre-existing channel on the network, whereas online streaming requires the network to effectively create and maintain an entirely new channel (a TCP connection) for every end device. When 50,000 viewers watched the entire fourth season of *Breaking Bad* in the twenty-four hours before the fifth season premiered on AMC, 50,000 identical copies of *Breaking Bad: Season 4* had to be pumped through the internet more or less simultaneously.[4]

Although resource intensive, this new model of the television channel affords a much higher level of personalization. The rise of cable television channels has already promoted the idea of tailoring content to niche audiences. But with Netflix's TCP connection streams, the "niche audience" has been divided down to its atomic unit: the individual. The Netflix user is presented with the ability to select exactly what they want to watch, as well as where, when, and how they want to watch it. With the help of a nearby OCA, this user does not have to wait for scheduling or download times. They can binge watch a season, choose an obscure documentary, or even "watch it again" — each choice they make is actualized in real-time. By making these decisions, the Netflix user interacts with the platform using their own tastes, preferences, and usage behaviors, which are constantly being reinforced by the company's sophisticated recommendation system.[5] In this sense, the user is *empowered* by their sense of individuality and their ability to choose, although this effect is not unique to Netflix. The emergence of "real-time" computing systems in the seventies provided the basis for human-computer *interactivity,* which has been understood by some as a first step towards the liberal subjectivity of the technology user.[6] Yet the notion of the streamer's sovereignty is not

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[4] McDonald, Kevin, and Daniel Smith-Rowsey. *The Netflix Effect: Technology and Entertainment in the 21st Century*. New York: Bloomsbury Academic, 2016. 194. Print.

[5] This system is a machine learning algorithm that likely runs on a cluster of high-CPU instances in the Amazon cloud, processing data on Netflix's entire customer base. I am not including these recommendations as part of the stream conceptual model, but it's another example of the relationship between infrastructure and the neoliberal subject within the Netflix ecosystem.

[6] Hu, Tung-Hui. *A Prehistory of The Cloud*. Cambridge, MA: MIT, 2016. 48. Print.

merely an emergent property of Netflix streaming's real-time interactivity, either. It is fully present in the company's rhetoric, which repeatedly emphasizes how the service empowers its users, liberating them from a previous era of "gatekeeper-restricted" media access. Netflix's understanding of this so called empowerment as a component of their platform's design establishes the basis for relating the neoliberal subjectivities of their users to the infrastructures that the company has invested heavily in to enable their platform. The motives behind establishing this relationship are presumably business related, however its effects are likely multifaceted, if not elusive.

While it is well understood that audiences now experience greater control in determining when and how they consume media, there are many consequences of this shifting paradigm still to be addressed. Having established a relation between the sovereignty of the Netflix user and the infrastructure of the platform, this paper will now assess the Netflix stream as a causal system; a chain of events centered around the moment the user selects a show and presses "Play Now." Given the infrastructurally intensive nature of streaming, a discussion of this stream's environmental impact is warranted. Unlike a consumer refrigerator or a sedan, the environmental impacts of streaming are more difficult to quantify. As a networked experience, the total energy usage of a given stream session arises from a set of distributed events, most of which are not visible to the end user. This effectively resembles the principal tenet of the cloud computing paradigm — to access sophisticated, intensive applications via lightweight and highly mobile interfaces by relocating the heavy lifting to some remote elsewhere.

As the cloud has proliferated, an increasingly common criticism of the data center industry has been that data centers are built in areas like Iowa and Virginia where cheaper fossil fuel-based electricity is readily available. A recent Greenpeace report, however, has

shown that most brand name tech companies like Netflix are already operating their data centers in carbon neutral ways (although vast amounts of electricity are still being consumed).[7] An article in *The Atlantic* relevantly titled “The Environmental Toll of a Netflix Binge” simply outlines the data center industry’s energy consumption and provides a criticism of the industry’s general failure to prioritize the environment over business interests, yet the specific environmental impacts of the binge remained largely unaddressed. Upon closer investigation into a Netflix stream, the bulk of the environmental toll is found not at the data center but at the network edge. Here is where the thousands of OCAs have been deployed, each having a footprint associated with its manufacture and continuous operation. Furthermore, Netflix replaces these on a yearly basis for performance reasons. The carbon footprint of Netflix’s Open Connect CDN is a significant component of the stream’s overall environmental impact, yet it is difficult to quantify due to the highly distributed nature of its operations. Kristian Kaufman, CEO of CDN company Akamai Networks, put it frankly: “when you are dealing with locating servers remotely, you have less control over the environment. To run a CDN, you focus on performance and reliability, with power efficiency somewhere down the list of requirements.”[8] For the Netflix stream, a carbon footprint cannot be traced back to some energy-sucking data center location. It’s footprint exists as the sum of distributed components, each of which are more related to the end user’s circumstances than to the corporation itself. Under the domains of separate local authorities, the environmental tolls of Open Connect are potentially beyond the reaches of Netflix’s abilities to be enforce an environmental responsibility even if the company were to make some Zuckerbergian pledge to full carbon neutrality.

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[7] Cook, Gary. “Clicking Clean: Who is Winning the Race to Build a Green Internet?” Greenpeace, Inc. 2017.
[8] Wong, Joon Ian. "The Internet Has Been Quietly Rewired, and Video Is the Reason Why." *Quartz*. Quartz, 05 Oct. 2016. Web. 08 May 2017.

Another significant portion of the stream's energy consumption, one that is often overlooked by criticisms of the cloud, is the final step beyond the network edge — the last wireless hop from the user's local access point to their device. A recent Bell Labs report profiles the power usage of "wireless cloud" technology, which groups data centers and wireless networks together to assess the energy impacts related to the growing popularity of accessing cloud services via wireless devices. It found that the wireless cloud's energy usage had a carbon footprint of 30 megatons of CO2 in 2015, an increase from 6 megatons in 2012 which is equivalent to adding 4.9 million cars to the road.[9] Furthermore, it found that 90% of this consumption is attributable to the wireless networks, with data centers only accounting for a mere 9%.[10] Although cellular networks account for most of this energy consumption, the statistic indicates that the final wireless hop is a major component of the stream's environmental toll. In the same ways that a tradeoff exists between resource consumption and user "empowerment" with Netflix's Open Connect CDN, there exists a tradeoff between the costs of wireless connectivity and the user's freedom of choice in how and where they want to stream (i.e. in bed or the kitchen counter versus a desk or the room with the cable box in it). Thus, the relationship between network technology and user subjectivity spans the logical and literal distance between Netflix's corporate operations and the user's private lifestyle via the environmental impacts it induces along the stream's supply chain.

Although the infrastructural systems involved in streaming are just as complex as the paradigm's resultant consequences, the Netflix stream is ultimately realized as a highly modern and highly comfortable consumer experience. Real-time access to an ocean of high definition videos, all from a razor thin laptop handled in bed like a magazine — it's a remarkable scene within the history of media technologies. The status of the stream's consumer is similarly

[9] "The Power of Wireless Cloud." CEET, Bell Labs and University of Melbourne. 2013.
[10] Ibid.

remarkable. As consumers, we now have an incredible amount of say over what, when, where, and how we want to watch. We've even been spared from the subtler emotional anxieties of video buffering — the implicit acknowledgment of technology's limitations and thus our ability to utilize it. Nevertheless, these comforts come with real environmental costs that are still hard to understand, especially from an individual's perspective. The complexity of the streaming supply chain is great enough that Silicon Valley's environmental concerns may only address a fraction of streaming culture's greater environmental impacts. What will remain unaddressed are the factors that lay at the intermediate stages of the streaming supply chain, between Netflix and the customer, factors more related to our expectations for the speed, accessibility, and portability of information than to our ability to recycle a laptop or buy eco-friendly products. As video's percentage of internet traffic continues to grow — as we continue streaming — it is crucial we find some way to keep these environmental factors in mind.