When Infrastructure Becomes Failure: A material analysis of the limitations of cloud gaming services

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After what feels like an eternity of waiting, I see another player. They are running across the wheat field, completely in the open. I quickly look down my magnified scope, placing the intruder in my field of view.

From my perch on the roof of this building, I have the perfect vantage point to use the Kar 98 I had picked up earlier in the match. It's a sniper rifle, powerful enough to down another player with a shot to the head from hundreds of meters away. But they're also loud. And slow. And I'm not the only player who has one.

I will likely only get one shot – the slow firing rate of the Kar 98 means that missing would give the other player enough time to duck down amongst the field of yellow wheat, disappearing from my sight. I line up my shot, hand moving slowly as I follow the target.

I click my mouse. Yet, my in-game avatar does not pull the trigger. Instead, a half second passes. Or perhaps only a tenth of a second. Not much time, but enough. Enough so that when my avatar does pull his trigger, the bullet does not fly into my opponent's head. Instead, I see a small cloud of dust shoot up where the bullet impacted the hill behind them. This, combined with the sound of the gunshot, is enough to give my position away. Within seconds, a returning shot ends the match.

Would I have hit my mark if that delay hadn't occurred? Maybe, maybe not. I'm only a casual player, and the Kar 98 is a difficult gun to use, so it's equally likely the shot would have missed regardless of input lag. In the moment, however, the culprit is clear. The lag was obviously to blame, no doubt caused by the cloud gaming service I am using to run PLAYERUNKNOWN'S BATTLEGROUNDS on my MacBook Air. I close the program in frustration. There's no point playing if I can't even hit anything.

Cloud gaming, again

In early 2017, technology company Nvidia made headlines when they announced GeForce Now – a digital game streaming service that runs on the cloud (McCormick, 2017). Similar to how Netflix allows users to stream television shows, and how Spotify allows users to stream songs, GeForce Now allows users to store and run games on a remote graphics processing unit (GPU) housed in a data center. The video output of these games can then be streamed to any personal computer (PC), with player inputs sent back to the data center over the internet. Nvidia, known primarily for manufacturing and selling GPUs, claims this service will be able to 'transform any Mac or PC into a high-performance gaming rig' (Nvidia, n.d.).

While services like Steam and Playstation Plus have already made use of the cloud for storing saved games and transferring accounts, a remote cloud streaming service has yet to become a mainstream reality in the world of digital gaming. For people with PC gaming experience, a service like GeForce Now is a liberatory promise – liberation from the large, expensive devices needed to run most modern day, big-budget games. A high-end gaming PC can cost upwards of $2000 CAD to build, with additional costs stemming from constant upgrades and the maintenance needed to keep the machine from breaking or becoming obsolete. This price has always been a barrier for entry to people hoping to play most new, graphically intensive, digital games. The high degree of technical knowledge needed to build and maintain a PC has only further cemented this particular sphere of digital games as the realm of hobbyists and obsessives – myself included.

In this light, Nvidia's GeForce Now can be seen as an equalizing force. No longer do people need thousands of dollars and a familiarity with computer hardware to enjoy high-end PC gaming. Instead, they simply need a functioning laptop and $25 for every 20 hours of play to obtain (what is marketed as) a near identical experience to playing on a high-end PC. Members of the tech and gaming press readily adopted this narrative when reporting on the service's ongoing beta period, publishing headlines such as 'NVIDIA proves the cloud can replace a high-end gaming rig' (Hardawar, 2018) and 'Nvidia's GeForce Now cloud gaming service feels like playing on a high-end gaming PC' (Chacos, 2018). Nvidia is also not the only company making moves to establish a cloud gaming service; Paris-based company Blade and New York-based company LiquidSky have both already launched beta tests for similar services to GeForce Now. Even massive tech companies have expressed interest in remote game streaming, with both Google and Microsoft currently developing cloud streaming platforms (Orland, 2018).

To an interested observer outside the industry, this move away from home hardware and towards the cloud may seem like a natural progression for digital games. Considering the growing ubiquity of other streaming media services, why should games be left out of the so-called ‘cloud revolution?’ For someone involved in the PC gaming community, however, Nvidia’s new service is far from novel, as there have already been several attempts to make cloud streaming games as ubiquitous as Netflix or Spotify. The most infamous of these services, OnLive, launched in 2010. As with GeForce Now, OnLive was met with a wave of positive press, with one tech journalist describing the service as ‘feeling exactly as if [he] had installed the software on [his] local computer’ (Bray, 2010). Another described OnLive as ‘the easy path to instant gratification gaming’ (Takahashi, 2010). Audiences did not agree. OnLive struggled to grow its user base despite the positive press, with user reviews citing high input latency and poor picture quality as major deterrents to regular use (Leadbetter, 2010). After laying off all of its employees, the company behind OnLive dissolved in 2012 – only two years after the launch of the service (Hollister, 2012). As other media took to the clouds, gaming stayed firmly on the figurative ground.

This may never change. The cloud is a source of infrastructural failure, a sword that hangs unwaveringly over the streaming game, ready to sever the player from their experience at any moment. This separation generates failure in turn: an unavoidable, unpredictable in-game failure that threatens to shatter the barrier separating games from reality. In the following essay, I describe the physical and technical limitations that cause infrastructure failure, and use evidence drawn from the fields of critical infrastructure studies and game studies to explain why this kind of externally introduced failure is so disruptive to digital games. Ultimately, I argue that infrastructural failure is an insurmountable obstacle for companies attempting to launch streaming services, and that u nless the cloud – or mainstream gaming – drastically changes, there may never be a “Netflix for games.”

Infrastructural failure

The problems that prevented OnLive from reaching the same level of ubiquity as Netflix or Spotify remain, and GeForce

Now does not appear to have a strategy to fix them. Despite what Nvidia's marketing appears to claim, high latency and subpar image quality in streaming cannot be eradicated with more powerful GPUs. These problems are consequences of infrastructure, caused by the distance between players and data centers, the quality of players' internet connections, and other material factors – all variables that Nvidia is unable to control.[1] The marketing used to sell GeForce Now and similar services masks this lack of control in order to hide the potential for infrastructural failure, which is an inescapable aspect of the cloud streaming experience. When the infrastructure supporting cloud gaming fails, that failure directly impacts the game being streamed. Visual and technical glitches can appear, altering the way players interact with the game world.

The most obvious of these potential glitches is input lag. When using a cloud service such as GeForce Now, a player interacts with the streaming game by entering inputs using a controller or keyboard. These inputs must then be sent over the internet to the remote GPU running the game, where they are translated into in-game actions. The player sees the effect of their inputs after the GPU's video output travels back through the internet to be displayed on their PC. This entire process can only happen as fast as the network can allow, with factors like the distance between the player and the GPU or the quality of the player's internet connection dictating the speed at which this information can be exchanged. If this process happens slowly enough, it manifests as input lag: a noticeable delay between a player's input and the corresponding in-game action taking place on their screen. This delay can sever the already tenuous relationship between player action and perception, a relationship all gameplay is ultimately dependent on. As described by Eugénie Shinkle (2008: 909), 'gameplay comprises a much more complex mesh of perceptual activity' than 'vision, visuality, and rational decision-making'. It is not enough that the player can still see the what happens in the game world – they must instead be able to perceive in-game events as the direct consequence of their actions. If perception can no longer be relied on by the player, then gameplay itself can no longer exist.

An example of input lag in *PLAYERUNKNOWN'S BATTLEGROUNDS.* Available at: https://www.youtube.com/watch?v=MdGBwrJ6rtI by Youtube user Crowbcat.

Another problem is video compression. As computer hardware becomes more powerful and games continue to strive for graphical fidelity, the amount of bandwidth needed to transmit a video feed from a big-budget game also grows accordingly. This is not much of a problem for people with access to high-end fibre-optic networks, but bandwidth limitations can result in people in rural or undeveloped areas being locked out of the service. Since cloud gaming providers do not own the infrastructure they use, and thus are incapable of upgrading internet cable networks to allow for higher bandwidth limits, they must instead use encoding algorithms to compress their video output to an appropriate size. Ideally, this compressed version of the video output is then decoded and expanded by the player's PC. However, if the network speed drops, the player's PC will not have enough time to properly decode the compressed video output before it is shown to the player. This causes the video quality of the game to drop accordingly. Video streaming services like Netflix and Youtube must also deal with this problem, but have the crucial advantage of predictability – video progresses in a linear fashion, and can thus be preemptively loaded onto the user's PC. Games, on the other hand, are unpredictable. As with live streaming platforms like Twitch, cloud gaming services are forced to decode video as it is received. Even for users with access to high-end network infrastructure, this can result in sudden and erratic drops in video quality (Vasquez, 2018).

But these difficulties are only a part of a larger narrative of failure. To understand why game streaming has not, and perhaps will not, become as popular as other forms of streaming media, we must go beyond identifying and describing the above-mentioned infrastructural limitations. We must also identify why these limitations appear as problems in the first place – the aspects of digital games, as a medium, that allow for these issues to manifest so intrusively. Infrastructural failure, after all, is not unique to games. In fact, failure could be considered a defining aspect of all transmitted media. Rosa Menkman (2011: 14), in her exploration of glitch art and culture, declares that 'what makes any medium specific is how it fails to disappear – as techné. To study media-specific artifacts is to take interest in the failure of media to disappear, or in other words, in noise artifacts'. These noise artifacts are the consequences of failure, manifesting when the infrastructure that is responsible for sending, carrying, and receiving electronic signals noticeably alters the transmission of information. This is when infrastructure becomes visible – as further explained by Susan Leigh Star (1999: 382) in her ethnography of infrastructure: 'The normally invisible quality of working infrastructure becomes visible when it breaks: the server is down, the bridge washes out, there is a power blackout. Even when there are back-up mechanisms or procedures, their existence further highlights the now-visible infrastructure'.

All streaming media relies on infrastructure, and is thus susceptible to the noise artifacts that serve as a physical manifestation of infrastructural failure. Every time a Hulu video stops to load in the middle of a scene or an iTunes song refuses to play, infrastructure is failing and, through this failure, is being made visible. People who use streaming services will inevitably have to deal with these visible manifestations of failure – and the frustration that comes with them.

Lisa Parks and Nicole Starosielski (2015: 16) explain that the experience of interacting with infrastructure 'during instances of inaccessibility, breakdown, replacement, or reinvention' can change the affective response people have towards these systems. If the infrastructural disruption is intense enough, the apathy most people feel towards infrastructure can shift into annoyance or frustration. What was once merely visible (Star, 1999), turns into the affective. Digital games are particularly vulnerable to this affective shift, particularly those games that are built around skill. Almost all big-budget "AAA" games require players to develop context-specific skills (such as aiming attacks, timing jumps, or dodging obstacles) to overcome rule-based challenges, an experience that is easily disrupted by the infrastructural problems caused by game streaming. If this experience is disrupted heavily enough, players will not be able to succeed in challenges within the game.

As explored in the fictionalized anecdote preceding this essay, these are the cases of infrastructure failure that make cloud gaming such a difficult endeavour. Shots that should have landed instead miss their marks, trivial jumps between platforms become treacherous leaps of faith, and normally slow moving obstacles become impossible to avoid. When infrastructure becomes failure, the player fails as well.

Generative failure

One of the digital games used in the marketing for Nvidia's Geforce Now, *PLAYERUNKNOWN'S BATTLEGROUNDS* (*PUBG*), is a competition. 100 unarmed players drop into an island, where they must scavenge for equipment and weapons. The last surviving person wins. Players can be taken down with only a handful of shots, and the rush to claim limited resources regularly leads to panicked firefights. In these moments, players can only rely on their skill at the game: their ability to react to danger, to use the right equipment and, most importantly, to aim quickly and accurately. However, in order to rely on their skill, players must also rely on their PC's ability to receive and process their inputs – or, in the case of a cloud streaming service, for their remote GPU's ability to receive and process their inputs. As shown in the anecdote above, this is where input lag becomes a matter of virtual life or death. If too much time passes between the player pressing a button and the corresponding action appearing on-screen, a disconnect is formed between the player's intention and the player's action. They become unable to act with purpose, and therefore unable to act skillfully. In fast, competitive game like *PUBG*, this disconnect is a death sentence.

The amount of time between input and action needed to cause this perceptual dissonance is around 200 ms for most people (Andres et al., 2016), but dedicated members of the PC gaming community consider input lag over 100 ms unacceptable (Display Lag, n.d.). In some cases, this 100 ms threshold can be exceeded entirely due to the processing time required by the game itself. The remote nature of cloud GPUs only compounds this problem, since every dip in a player's network speed now comes with an increased delay between input and action that would not have occurred otherwise.

An example of a player struggling to aim due to input lag introduced through cloud streaming. Available at https://www.youtube.com/watch?v=meFjUC4HLks&t=198s by Youtube user Solidrev.

Input lag is not the only potential source of frustration introduced by connecting to a remote GPU. Other problems caused by infrastructural failure, such as graphical errors or disconnections, can also contribute to a wrong move, an accidental death, or a lost match. Beyond being merely visible, cloud-streaming infrastructure turns into an affective force upon breakdown – or even an *effective* force. While infrastructure has been described by Parks (2015: 355) as 'stuff you can kick', a reference to the material nature of distribution systems, this is an example of infrastructure kicking back. Input lag and other network issues exert a material force upon people, creating a challenge that exists outside of the game-world and that cannot be overcome within the game. With cloud streaming, if the network fails, the player fails. Failure begets failure.

But failure itself is not the issue. As described by Jesper Juul, competitive, skill-based games like *PUBG* are largely about failure. As Juul (2013: 30) states, 'video games are the art of failure, the singular art form that sets us up for failure and allows us to experience and experiment with failure'. *PUBG* is a good example of this principle. Though 100 players enter every match, only one can ever emerge the victor. The rest will fail, learn from their mistakes, and try again. Over time, players become more skilled at the game, and more likely to win any given match. But this process takes time. Most *PUBG* players will fail dozens, if not hundreds of matches before their first victory.

This cycle of failure is the primary draw of skill-based games. As Juul (2013: 74) explains, failure allows for a game where 'we can continually improve our skills, and whenever we fail, we have a chance to reconsider our strategies, to calibrate and reconsider our toolset'. Players submit willingly to this 'consensual failure' in order to improve themselves and, with enough play, to achieve the a feeling of personal growth and achievement. Crucially, the ability for players to improve and succeed is contingent on failure being conquerable – the rules of the game must be consistent and comprehensible, allowing for players to develop a set of skills that allows for the successful navigation of these rules. If players are unable to do this, the skill-based game will not be considered 'fair' (Juul, 2014: 79). Establishing 'fairness' in a game is contingent on the rules of the game remaining intact. Rules, in this case, constitute the limitations and affordances allowed to players within the game, functioning as both a restriction on player options while simultaneously acting to establish other potential actions (Juul 2005: 58). As noted by Johan Huizinga in his theorizing of the 'magic circle' (the idea that games create distinct "worlds" for players to inhabit) a game's rules are what separates the play-space of game from the rest of reality:

> All play has its rules. They determine what "holds" in the temporary world circumscribed by play. The rules of a game are absolutely binding and allow no doubt… Indeed, as soon as the rules are transgressed the whole play-world collapses. The game is over. The umpire's whistle breaks the spell and sets "real" life going again. (1949: 11)

This is how infrastructural failure undermines skill-based digital-games. By transgressing the rules of the game by introducing input lag, graphical errors, and other technical issues – the boundary between the game and "real life" is also transgressed. Infrastructure, a material system firmly rooted in the real, infringes upon the virtual. In doing so, players become unable to work within a consistent, understandable set of game rules, and the promise of personal improvement is broken. The magic circle is shattered. What appears instead is merely a manifestation of failure, one that caused failure in turn. The failure that occurs when any digital gaming infrastructure fails is not the same as the failure that becomes visible when other media fails. Instead of merely being visible, it becomes affective and effective – a generative failure, creating more failure in its wake. This player failure, which is created through the failure of infrastructure, is a 'non-consensual failure'. As opposed to the consensual failure players enter into whenever they play a skill-based game, this failure can never be overcome by players from within the game.

Cloud-based gaming relies on a remote GPU, introducing a new source of potential infrastructural failure, and therefore a new way for reality to infringe upon the world of the game. The technical issues caused by this failure exist outside of the game's rules, and cannot be overcome by skill. They exist only to affect users, to be a source of frustration and annoyance that can appear at any time without warning or recourse. This is why cloud-based gaming has already been rejected by many players – if this failure happens often enough, or at the right times, then frustration quickly turns to defeat. Players are 'taken out of the game', affected by real-world intrusions they are incapable of affecting back. What point is there in struggling against forces outside of your control?

The future of cloud gaming

While the success and ubiquity of streaming media grows with every passing year, digital game streaming has yet to reach the cloud. Skill-based games, on a fundamental level, are too fragile of an experience to reliably operate from a distance. Dependence on a remote GPU introduces a potential source infrastructural failure, which in turn causes players to fail, disrupting the ability of digital games to offer skill-based challenges built on an immutable set of understandable rules. With game streaming, infrastructure becomes failure – and failure is a strong deterrent when the alternative (simply playing games on a PC or console) is already a valid option. Any streaming company that wants to be accepted by players has to prevent infrastructural failure from causing player failure, to solve the problems that were first identified even before OnLive launched in 2010 (Leadbetter, 2009). OnLive was unable to solve these problems, and was unable to find success because of this. So can Nvidia's GeForce Now and the other new attempts at cloud gaming avoid failure in a market that has been historically defined by failure?

Unless these companies plan on laying down fiber optic cables across the country, or on building data centres in every American city, then no. While the service may work smoothly enough for users that find themselves close to cloud gaming data centers, or users that have access to high-speed internet, most people who regularly play digital games will likely still avoid cloud gaming. What's more, companies hoping to remotely stream games have to contend with the entities that actually control network infrastructure in North America: internet service providers. Broadband caps enforced by companies like Sprint and AT&T are another obstacle to fast, reliable game streaming, and would affect users regardless of their location or access to fiber-optic cabling.

Of course, there is another option – the games themselves could change. While I have established that competitive, skill-based games cannot work in a streaming environment, other types of games could be remotely streamed with little impact to the way the game operates. Turn based games avoid issues with input lag by not running in 'real time', and role-playing games often move at a slow enough pace that mild latency would only have a negligible effect on game performance.

Some games avoid the problem entirely by removing skill as a barrier to progress, meaning that input lag and other infrastructure failures, while still annoying, are unable to generate failure within the game. These non-skill-based games, some of the most notable of which include The Fulbright Company's *Gone Home* and Cardboard Computer's *Kentucky Route Zero*, often explore topics and themes outside of the narrow scope of mainstream video games, including queer issues, deindustrialization, and mental illness. By removing skill-based challenges and focusing instead on exploration, decision making, and player experiences, non-skill-based games actively challenge the violent, competition-oriented games that serve as the status-quo in the digital games industry. Cloud streaming could thus lead to an increase in the popularity of non-skill-based games – or, as Jack Halberstam (2011: 3) explains in *The Queer Art of Failure,* 'failure allows us to escape the punishing norms that discipline behaviour and manage human development', allowing for the emergence of new ways of doing and thinking. The failure of skill-based games to adapt to the cloud could be an opportunity to escape the heteronormative, masculine hegemony that dominates mainstream gaming, shifting a culture obsessed with skill and competition to one that prioritizes collaboration, creativity and critical thinking.

Unfortunately, the companies racing to legitimize cloud streaming are not doing so in order to shift the culture of mainstream gaming. Instead of helping to change games to better fit the cloud, Nvidia and their competitors are instead seeking to force the cloud onto currently popular games – as evidenced by their exclusive use of skill-based multiplayer games like *PUBG* and *Fortnite* in their promotional material. (Nvidia, n.d.) But skill-based digital games are about consensual failure, which is contingent on a coherent set of rules. Because infrastructural failure is generative, because it can lead to an insurmountable failure that shatters the rules that compose game worlds, skill-based digital games may never work in the cloud. If game streaming could work, then it would have to be in a very different cloud from the one we have now. A cloud that is less about centralization and control, and one that is more concerned about experience and access. One that understands the game cannot simply be removed from the player, separated over hundreds of kilometers, and made vulnerable to the invasions of the real.

Note

1. The relationship between infrastructure and digital games has also been explored by Conaway (2017).

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