The Competitive Subculture of Cryptocurrency Mining

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Cryptocurrency mining is computationally intensive; for high returns, miners need graphics cards or application-specific integrated circuits (ASICs). The more that is used, the higher the return rate. On a blockchain, an algorithm responds to the consequent congestion by increasing the difficulty of mining, which can curtail profits (Altman, n.d.). To mine a block and gain the reward, cryptocurrency miners therefore strive for more computational power in proof of work (PoW) currencies. In the year 2021, cryptocurrencies Bitcoin and Ethereum have reached their all-time-high prices, leading to a surge in miners and a worldwide shortage of graphics cards used by gamers. Thus, miners, gamers, and cryptocurrency mining equipment manufacturers shape the subculture of cryptocurrency mining.

Isolation and Stress

Some miners have attempted to simplify mining through malicious distributed denial-of-service (DDoS) hacking attacks on mining pools (Wu et al., 2020). Such attacks sabotage rivals mining the same currency. Wu et al. propose a Nash learning algorithm for optimal attacks (2020). Because cryptocurrency is decentralized, hackers have sufficient anonymity to steal currency.

Cryptocurrency miners also try to optimize the amount of cryptocurrency that can be generated by their hardware through means such as overclocking. Sukharev describes one such method in his research, utilizing an equation to calculate the effectiveness where k = (Hashrate + (1 – lost)/N) “where Hashrate - mining speed, lost - share of incorrectly calculated hashes, N - the power consumption” (Sukharev, 2020). It utilizes three main overclocking techniques: GPU memory overclocking, core overclocking, and undervolting to see which method is best.

Cong et al. also gives insight on the valuation of cryptocurrency and how competition effects its valuation. As more miners join the peer-to-peer network, mining difficulty increases, leading to the creation of more mining pools where miners can split a reward. And as the mining reward decreases, miners shift to profiting from transaction fees of users that want their block mined in over others (Cong et al. 2020). This is consistent with research by O'Dwyer et al., which notes that carbon emissions due to Bitcoin mining has been steadily increasing over time. At the time of O'Dwyer et al.'s paper, Bitcoin mining was generating approximately 3,654 metric tons of carbon dioxide per year, which was on par with the electricity consumption of Ireland, and still growing (O'Dwyer et al., 2014).

Since May 2021, when China banned cryptocurrency mining, many miners relocated from China to the United States. For U.S. cryptocurrency mining facilities, such demand has meant growth. Christopher Herbig, the lead technician at Compute North in Nebraska, reports: "We doubled in size" (Ruwitch & Feng, 2022). Mining hardware companies AMD and Nvidia are competing for the fast-growing market (Delventhal, 2022).

Most miners work in pools that combine their computational power, usually to mine a block and spread the reward. For Bitcoin, highest hashrate pool is foundrydigital.com at 67.83 EH/s as of December 9, 2022 (MiningPoolStats, n.d). This is equivalent to about 574,576,271,186 RTX 4090 graphics cards hashing at 118 MH/s (Tarman, 2022).

Many cryptocurrency miners are seeking to make extra money on the side. One miner who worked from his college dorm reported: "'It was unbearable... I had fans running, I had the window open.'" He used dryer tubes to direct hot air out of his room (Rothaar, 2018). Sometimes, employees use their employer's resources to mine cryptocurrency: "In March 2018,

an employee at Florida's Department of Citrus (FDoC) was arrested on charges of allegedly using state-owned computers to mine Bitcoin and Litecoin. It was alleged that he had used $22,000 worth of state money to purchase 24 graphic processing units and had caused the department's utility bills to rise by over 40%" (Rothaar, 2018).

Mining the Ethereum cryptocurrency as profitable as it used to be. Ethereum has the second highest cryptocurrency market capitalization (Slickcharts). On September 15, 2022, Ethereum officially switched to its proof-of-stake chain. After this shift, the coin does not need to be mined on graphics cards anymore since the difficulty was removed. This caused an influx of cryptocurrency mining cards not to be used anymore. A miner's choices then, are to:

1. Sell off their graphics cards
2. Move to another cryptocurrency to mine

The first choice would cause the miner to possibly break even on their investment but increase the supply of the used mining cards market. The second choice would cause more competition in other coins, increasing the difficulty in the coins, and lead to overall less profitability.

One such example was highlighted by Team Recurrency, a blog. The author describes his experience with mining bitcoin. He first started with a dual-GPU rig in 2013, when Bitcoin was just becoming popular. He states that "In 2013, I earned $4/day in BTC and spent $2/day on electricity" (Team Recurrency, 2022), which allowed him to passively earn income. However, this was not always without hiccups – he described that "The rig needed more attention than my 2-year-old daughter" (Team Recurrency, 2022). At the time of 2013, the price of GPUs was also starting to increase as the profits from mining Bitcoin with GPUs were increasing due to the price of Bitcoin increasing also. Thus, the author decided to sell his GPUs and invest his profits to mine with an ASIC, which was more power-efficient: "After just a couple of months, I parted

out the mining rig and sold the GPUs for a nice profit. Radeon HD 5870s were going for above-market prices because BTC had risen to $250 making mining more profitable and GPUs harder to find." (Team Recurrency, 2022)

This is supported by the research institute, Jon Peddie Research as well. Using "the difference between the trending normal attach rate and the current rate" they were able to predict how many graphics cards that were bought ended up being used for mining. According to them "The model predicts that about 25% of the AIBs shipped in Q1'21 went to miners and speculators. That's approximately 700,000 high-end and midrange AIBS in Q1'21. And the market value is about $500 million—a half a billion dollars." (Peddie, 2021)

In their research, Jon Peddie also describes a practice known as scalping graphics cards: "That has led to the introduction of buying bots that crawl the web looking for AIB inventory and, when found, immediately buy it. The bot owners then take the AIBs, plug them into their farm, raise the price, and offer them on eBay. And some miners will buy them from eBay sellers. Not only new AIBs but AIBs from the last generation" (Peddie, 2021). This is particularly important because even when new supply comes in, it ends up being a race between bots and real users to get their hands on these cards, and usually, robots programmed to refresh a page every few seconds for new stock to check out will be much faster. One such example the author shows is a 3060 Ti Founders Edition card – which has an MSRP of only $400, being sold on eBay for $960 on auction with 14 bids on it already (Peddie, 2021). They also attribute the increased cost of graphics cards to increase component costs (Peddie, 2021), which makes sense. During COVID, there was a large chip shortage because foundries had to stop/slow down production due to workers being spread the virus. According to JP Morgan, "In the simplest terms, the chip shortage was due to strong demand and no supply. This goes back to COVID-19 lockdowns in

the second quarter of 2020, when demand for work-from-home technology increased exponentially and automakers found themselves competing for the semiconductor capacity in Asian foundries. These supply chain issues caused upheaval in the auto industry, holding up production and denting sales" (JPMorgan, 2023).

Cryptocurrency manufacturers know of the profitability of cryptocurrency mining, and thus use the opportunity to raise prices on goods. In August 2021, at a peak in mining profitability, the average price on eBay for a 3080 10GB graphics card was $1643 (Schiesser, 2021). The MSRP for this card was only $599. However, as of February 16, 2023, when mining is not as profitable anymore, the same card is being listed for $419.99 on Best Buy (Mujtaba, H.).

Among the many cryptocurrency mining communities on the internet, the Reddit subreddit "r/HeliumNetwork" has 101 thousand members and thousands of daily active users. Miners share techniques and offer advice. To boost rewards, one Reddit user "Swapped out to a 5.8 dBi placed 11.5 ft up on my roof, reporting: "Uptick in rewards almost immediately. Now witnessing 20+ hotspots daily and rewards have bumped up to $2-3 every 24 hours" (fees_waved, 2022).

As briefly mentioned before, some miners set up extremely large "mining farms" as well with the goal of generating large profits. CoinCentral highlights the top five largest ones: Bitmain, Giga Watt, Hut 8, Bitfury, and Bcause (Hamilton, 2018). Each of these mining farms have their own methods to maximize profits. Giga Watt in Washington uses over 1700 GPUs and "The facility can remain competitive in the Chinese dominated market through the use of inexpensive hydropower that is readily available in Washington State" (Hamilton, 2018). Bitmain Ordos sits at the largest – CoinCentral states that "This gargantuan mining operation

consists of 25,000 machines that process $250K worth of BTC daily" and "As you may have guessed, running this operation isn't cheap with the electrical cost exceeding that of a small town at around $39,000 daily" (Hamilton, 2018).

Cryptocurrency miners compete with PC gamers for a limited supply of graphics cards, driving prices up and causing tension. As a result, many gamers go to social media platforms such as Reddit to voice their complaints: "I don't think any one minded crypto mining a decade ago, because it wasn't causing any issues. But as more people jumped on that band wagon, It created a card shortage and price hikes. Many gamers only wanted a single card…" "they just wanted a nice one, and that was something they just couldn't get" (OHwenWOWsen, 2022). In a Reddit post "Nvidia's GeForce GPU shortage isnt' improving anytime soon", Reddit user lxs0713 states "I'm so over crypto as a currency. Bitcoin only worked because it built up its relevancy over time and was able to slowly cement itself as a legitimate currency. But now everyone and their mother wants to get in on the craze and you have all sorts of cryptos popping out…" "…And that's without even getting into the enormous waste of electricity that it is. Just looking at what happened in Texas earlier this year or what we deal with in California every fire season, it shows that our grids aren't that robust. So maybe we should be using our electricity on stuff that actually matters, instead of wasting it on virtual mining. At least with gaming people are getting entertainment and thus something of value" (lxs0713, 2021). At this time, this comment has 61 upvotes, signifying that many other users have similar opinions. The reply to the comment with 60 upvotes by user Vendetta1990 states "I have never hoped for something to implode in on itself, as much as for crypto… We have seen how miners have completely f[*]cked up the GPU market during the last 6 months, in the process ruining what many people consider to be a hobby… Lets hope for the biggest bubble burst ever seen, I want these f[*]cking

pr[*]cks to lose as much money as possible" (Vandetta1990, 2021). This further backs the first comment albeit in a more profane way, emphasizing the anger that PC gamers have felt.

Many PC gamers have also just given up and tried to switch to alternatives options instead. In a blog post by Richard Devine, "In the UK where I live you're looking at about £400 for an RTX 3060 right now. It's a fantastic graphics card, I have one in my collection of PC parts. But it's not even technically the "mid-range" anymore and it's that price. The last graphics card I bought at launch was an AMD RX 5700 and that was £370 at the time. But even AMD cards don't really have price on their side anymore" (Devine, 2022). Instead, he chose to try cloud gaming, which is using a cloud service to stream games to run on his computer for a monthly fee (Devine, 2022). One such service is Nvidia GeForce Now, which, as the name implies, is owned by Nvidia, one of the main manufacturers of graphics cards. Richard states that "Nvidia GeForce Now has a tier that offers its players the chance to play games on an RTX 3080. It's the most expensive tier, sure, but compared to actually buying an RTX 3080 you would get about five years' use from it for the same money. And Nvidia is bound to keep upgrading it. But the simple fact is this: My cloud gaming PC is more powerful than my local gaming PC…" "…I'm enjoying gaming again, more than ever before, and it has nothing to do with having splurged on a new, insanely powerful graphics card. By embracing the cloud I can play amazing-looking, high-frame-rate games on a Chromebook. Or my iPad. Or there's the Steam Deck, which is the only way I've played local PC games since it arrived at the end of March" (Devine, 2022), showing that some gamers have found a way to circumvent having to pay inflated prices for a GPU during the shortage.

Another alternative that Richard describes is using a Steam Deck, a handheld game console that recently launched. This console isn't as highly sought after by miners due to the

limited graphics capabilities. It's 720p screen means that it doesn't need to work as hard PC/Laptop graphics cards. It runs many modern PC games reasonably well according to Devine: "Performance on the Steam Deck has proved that you don't need a stupidly powerful, stupidly expensive graphics card to have a good time. You could say the same about the Xbox Series X and PlayStation 5. PC gaming used to feel like the absolute best way to play, now, it just feels like a massive money pit. And I'm not sure it's worth it anymore" (Devine, 2022).

To keep PC gamers interested in buying graphics cards, graphics card manufacturers have also tried to combat the use of their products for cryptocurrency mining. One such way is by throttling their graphics cards when it is detected that mining software is being used (Benson, 2021). For their 30 series GPUs, Nvidia began manufacturing Lite Hash Rate(LHR) versions of their cards and stopped producing Full Hash Rate(FHR) versions in 2021 after many complaints from gamers of them being always out of stock: "I didn't buy the 1080 when 20 series rtx cards came out, and now I can't buy a 20 when the 30 cards came out, and I most certainly can't get a 30. WHEN HAVE I WAITED LONG ENOUGH?" (Doc_Lewis, 2021). On Nvidia's blog, they state "To help get GeForce GPUs in the hands of gamers, we announced in February that all GeForce RTX 3060 graphics cards shipped with a reduced Ethereum hash rate" (Weubbling, 2021). Their blog heavily highlights how the graphics cards should be for gamers such as in the sub headers for each of their paragraphs: "Halving Hashrate", "Clear Communication to Gamers", and "GeForce is Made for Gaming" (Weubbling, 2021).

However, reception by gamers to Nvidia have been mixed. Some users blame the supply chain while some blame the graphics card manufacturer for the limited supply. One reddit user xosfear notes that "NVIDIA have said that they predict supply should catch up with demand around June/July. Believe it when I see it tbh" (xosfear, 2021). Which had 12 upvotes. While

another user, Ittybittyspooder, states “Tbf, I trust nvidia more than the government” (Ittybittyspooder, 2021) as a reply, which had a similar amount of upvotes at 10, indicating that users had varying opinion. However, even after supply started stabilizing, Reddit users noted how prices were still high: “Notice how the 3000 series are actually available, they're just like $200+ above their msrp…” “…When covid shortage happened, they flat out weren't possible to buy…” “…Nvidia is limiting supply to keep prices high. When people don't buy at a certain price, after some time the price goes down until it reaches a palatable point” (whomad1215, 2022).

Another alternative to buying graphics cards for gamers was also to buy gaming laptops. These are laptops that contain mobile graphics cards. However, cryptocurrency miners also began buying up gaming laptops when graphics cards became out of stock. A Weibo user, BTCer has created a gaming laptop mining farm, uploading images of hundreds of gaming laptops stacked on shelves, across tables, and on floors of a warehouse (harukaze, 2021). Many responses to this tweet are in disapproval. Self-proclaimed casual gamer CMDR Mardante Soliest responded “Normally I`m not this outspoken on here... but.. I hope it all burns down. You selfish pricks!” (CMDR Mardante Soliest, 2021). Another gamer comments, “Fu... Miner” (FishtownMoDDing, 2021). Dr. Adrian Wong, founder of the Malaysian technology news and information website Tech ARP, shared on Tech ARP how much this farm might be able to make. “We had earlier shared about how a Bilibili content creator used an RTX 3060 laptop to mine 0.00053009 ETH while she sipped her coffee at Starbucks for 2 hours. Based on her experience, we can guesstimate that the average GeForce RTX 3060 laptop will be able to produce…” “…2.3217942 ETH per year…” “…Chinese electricity costs about RMB 0.545 (US$0.084) per kWh. Assuming each laptop uses about 250 watts of power (including whatever external fans

they may be using), that works out to about RMB 1,200 or US$186 per year…" "…As of 11 February 2021, Ethereum is priced at US$1740. So here's roughly how much this cryptocurrency mining farm would make, at that price…" "…900 laptops: $3,468,530 per year…" "…So there you have it – this small cryptocurrency mining operation can potentially make almost US$ 3.5 million in a single year" (Wong, 2021). He also further explains that factoring miscellaneous costs for setup and buying the laptops, "…their net profit for the 900-laptop mining farm would be US$2,368,530 per year, at current prices" (Wong, 2021). So according to this, creating large mining farms can be very profitable despite the high setup costs, which further encourages people to mine using gaming hardware with powerful discrete graphics cards as well as further decreases the number of discrete graphics cards that can go to gamers.

Considering the laptops used in the previous paragraph, RTX 3060 laptops, we can estimate how many gamers use it compared to how many are produced. According to Steam's hardware survey, about 12.2% of users used a 3000 series laptop GPU in November of 2022 (Steam, 2023). And in 2022, about 17.5 million gaming laptops were produced (Alsop, 2022). And with Steam's 120 million monthly users in 2021 that have only grown (Dean, 2021), we can do the math: 12.2%*120 is roughly 14.64 million gamers using a 3000 series laptop on Steam. This accounts for roughly 83% of gaming laptops produced in 2022. This leaves only about 17% that can be used for mining, people that use discrete laptop graphics cards for work, AI work, etc. This doesn't even include the number of laptop gamers that use other gaming websites besides Steam such as Epic Games Store, GOG.com, Microsoft Store, etc. No wonder there is a shortage of gaming laptops that can be used as an alternative to buying a graphics card for a desktop PC, especially considering the skyrocketing of cryptocurrency miners in recent years.

Over the course of the graphics card shortage, dynamics between graphics card manufacturers, cryptocurrency miners, and gamers have been amplified. Miners looking for a profit use graphics cards to mine while gamers compete for the same hardware for video games. Miners have tried many ways to generate larger profits at the expense of gamers. Interactions between both gamers and miners can become tense and sometimes hostile as demonstrated through their numerous encounters over the internet. Feelings about graphics card manufacturers by gamers are mixed while graphics card manufacturers, stuck in the middle of the situation, look for ways to appease both gamers and miners while keeping supply high enough so that everyone can get GPUs.

References

Alsop, Thomas (2022, December 12). Global gaming laptop market production 2022-2028. *Statista.* https://www.statista.com/statistics/1350350/global-gaming-laptop-market-production/

Altman, Eitan, et al. (2020, January 1). Blockchain Competition between Miners: A Game Theoretic Perspective. *Frontiers*. https://www.frontiersin.org/articles/10.3389/fbloc.2019.00026/full.

Athey, S., & Catalini, C. (2020, January 17). The economics of cryptocurrency mining: Market dynamics, miner rewards, and cryptoasset valuations. National Bureau of Economic Research, Working Paper 24717. https://www.nber.org/papers/w24717.pdf

Benson, J. (2022, February 18). Nvidia Making Graphics Cards Less Desirable to Ethereum Miners. *Decrypt*. https://decrypt.com/71316/nvidia-making-graphics-cards-less-desirable-ethereum-miners

CMDR Mardante Soliest. (2021, February 10) Mining in China (Tweet). *Twitter*. https://twitter.com/CmdrSoliest/status/1359427105898041349

Cong L., Li, Y, et al. (2020, May). Tokenomics: Dynamic Adoption and Valuation. National *Bureau of Economic Research*. http://www.nber.org/papers/w27222

Dean, B. (2021, April 13). Steam Usage and Catalog Stats for 2022. *Steam.* https://backlinko.com/steam-users

Delventhal, S. (2022, July 18). AMD, Nvidia at risk on new cryptocurrency chip. *Investopedia*. https://www.investopedia.com/news/amd-nvidia-stock-risk-new-cryptocurrency-chip-china/

Devine, R. 2022, May 29). Why I might never buy a graphics card for gaming ever again. *XDA.* https://www.xda-developers.com/why-i-might-never-buy-a-graphics-card-for-gaming-ever-again/

Doc_Lewis. (2021). Are all GPUs out of stock? (Reddit Post). *Reddit.* https://www.reddit.com/r/buildapc/comments/kwjfko/are_all_gpus_out_of_stock/

fees_waved (2022, May). [Rant] The amount of whining on this sub has gotten unreal (Reddit post). *Reddit*. https://www.reddit.com/r/HeliumNetwork/comments/udq064/rant_the_amount_of_whining_on_this_sub_has_gotten/

FishtownMoDDing. (2021, February 13) Mining in China (Tweet). *Twitter*. https://twitter.com/Sponge_BomB86/status/1360574792865370117

Hamilton, D. (2018, May 4) The Top 5 Largest Mining Operations in the World. *CoinCentral.* https://coincentral.com/the-top-5-largest-mining-operations-in-the-world/

harukaze5719. (2021, February 9). Mining in China (Tweet). *Twitter*. https://twitter.com/harukaze5719/status/1359169998938324999

Ittybittyspooder. (2021). GPU Shortage / High Prices explained (Reddit Post). *Reddit.* https://www.reddit.com/r/graphicscard/comments/m7raae/gpu_shortage_high_prices_explained/

JPMorgan. (2023, April 18). Supply chain issues and autos: When will the chip shortage end? *JPMorgan*. https://www.jpmorgan.com/insights/research/supply-chain-chip-shortage#:~:text=While%20the%20COVID%2D19%20pandemic,on%20an%20already%20stretched%20industry

Peddie, J. (2021, June 15). Crypto-mining's half a billion dollar impact on AIB sales. *Jon Peddie Research*. https://www.jonpeddie.com/news/crypto-minings-half-a-billion-dollar-impact-on-aib-sales/

lxs0713, (2021). Nvidia's GeForce GPU shortage isn't improving anytime soon (Reddit Post). *Reddit*. https://www.reddit.com/r/pcgaming/comments/m5nvqx/nvidias_geforce_gpu_shortage_isnt_improving/

MiningPoolStats. (n.d.). Bitcoin mining pools. *MiningPoolStats*. https://miningpoolstats.stream/bitcoin

Mujtaba, H. (2023, February 15). NVIDIA GeForce RTX 30 GPUs See Huge Price Cuts At BestBuy: 3090 Ti For $880, 3080 Ti For $720, 3080 For $420, 3070 For $300 US. *wccftech.* https://wccftech.com/nvidia-geforce-rtx-30-gpus-huge-price-cuts-bestbuy-3090-ti-880-us-3080-ti-720-us-3080-420-us-3070-300-us/

OHwenWOWsen. (2022, October). Why do pc gamers and crypto miners hate each other so much? (Reddit post). *Reddit.* https://www.reddit.com/r/pcmasterrace/comments/wdtz07/why_do_pc_gamers_and_crypto_miners_hate_each/

O'Dwyer, K. J., et al. (2014, September 29). Bitcoin mining and its energy footprint. 25th IET Irish Signals and Systems Conference (ISSC), 280-285. https://ieeexplore.ieee.org/document/6912770

Rothaar, T. (2018, August 14). Students & Working Adults Are Mining Cryptocurrency on the Down-Low. *Medium*. https://teresarothaar.com/students-working-adults-are-mining-cryptocurrency-on-the-down-low-150a982c995

Ruwitch, J.; Feng, E. (2022, February 24). How the U.S. benefits when China turns its back on Bitcoin. *National Public Radio*. https://www.npr.org/2022/02/24/1081252187/bitcoin-cryptocurrency-china-us

Schiesser, T. (2021, September 21). GPU Availability and Pricing Update: September 2021. *Techspot*. https://www.techspot.com/article/2330-gpu-pricing-2021-update/

Slickcharts (2023, February 16). Cryptocurrency Market Data. *Slickcharts*. https://www.slickcharts.com/currency

Steam (2023, March). Steam Hardware & Software Survey: March 2023. *Steam*. https://store.steampowered.com/hwsurvey/videocard/?sort=name

Sukharev (2020, March 19). Hardware Overclocking to Improve the Efficiency of Ethereum Cryptocurrency Mining. *Institute of Electrical and Electronics Engineers.* *https://ieeexplore-ieee-org.proxy1.library.virginia.edu/document/9039491*

Tarman, M. (2022, September 22). NVIDIA RTX 4090 specs and mining hashrate. *NiceHash*. https://www.nicehash.com/blog/post/nvidia-rtx-4090-specs-and-mining-hashrate

Team Recurrency (2022, March 22). How Much Did Cryptocurrency Mining Inflate GPU Prices? *Priceonomics.* https://priceonomics.com/how-has-cryptocurrency-mining-influenced-gpu-prices/

Vendetta1990, (2021). Nvidia's GeForce GPU shortage isn't improving anytime soon (Reddit Post). *Reddit*. https://www.reddit.com/r/pcgaming/comments/m5nvqx/nvidias_geforce_gpu_shortage_isnt_improving/

Weubbling, M. (2021, May 18). A Further Step to Getting GeForce Cards into the Hands of Gamers. *Nvidia.* https://blogs.nvidia.com/blog/2021/05/18/lhr/

whomad1215. (2022, December). Why there is still Nvidia new gpu shortage? (Reddit Post). *Reddit*. https://www.reddit.com/r/buildapc/comments/zs789g/why_there_is_still_nvidia_new_gpu_shortage/

Wong, A. (2021, February 13). This RTX Laptop Mining Farm Could Make $3.5 Million / Year! *Tech ARP*. https://www.techarp.com/computer/geforce-rtx-laptop-mining-farm/

Wu, S., Chen, et al. (2020, March 13). Survive and Thrive: A Stochastic Game for DDoS Attacks in Bitcoin Mining Pools. IEEE/ACM Transactions on Networking. *Institute of Electrical and Electronics Engineers*. https://doi.org/10.1109/TNET.2020.2973410

xosfear. (2021). GPU Shortage / High Prices explained (Reddit Post). *Reddit.* https://www.reddit.com/r/graphicscard/comments/m7raae/gpu_shortage_high_prices_explained/