**Examining the carbon footprint of select digital technologies**

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|  | **The carbon footprint of digital technologies is significant and poses considerable concerns to the environment.** |
|  | Today's world is powered by the consumption of various digital services whose effects may not be immediately visible to the public at large. We need to maintain vast amounts of data in huge server farms and facilitate near instantaneous access to this. Also, we now routinely run various types of services powered by AI/ML models which are in turn trained on specialized hardware farms. All of these consume tremendous amounts of energy and generate enormous amounts of heat. The generation of the former and the dissipation of the latter constitutes the most impact on the world's environment in general. |
| **Data storage/cloud infrastructure** | whenever we turn to Netflix to stream movies or YouTube to watch music videos, we are dependent on a data cloud infrastructure whose simplicity on the user side belies its size and complexity on the infrastructure side. Estimates for the total energy use have been as large as the combined energy production of entire developed countries (Lorenzo Posani, 2019) - and shows every sign of increasing. Network bandwidth is absolutely dominated by media streaming sites and their attendant footprint is staggering; by some estimates one video alone could account for 367,000 tons of CO2, equivalent to 850K barrels of oil or the amount of energy 40000 US homes consume in a year (Chan, 2018). Preeminent technology providers widely acknowledge this; the Googles, Facebooks and Microsofts are already looking to curb energy costs and carbon emissions through various means. |
| **AI/ML/Compute services** | Similarly, the ubiquitous AI/ML services we now regularly run on this infrastructure in plain sight hides the complexity and energy needed to create these in general. A considerable number of these AI services that recognize your voice, find the fastest route from your house to your work, or discover the latest pictures of your dog from your latest vacation album all depend on computer models; these are created on specialized hardware running exceedingly high number of software processes. For example, while a typical American might expel 36k lbs. of CO2 a year, training a sizeable natural language processing (NLP) model for increased accuracy can easily hit 600k+ lbs. CO2 (Emma Strubell, 2019). High performance computing, needed to run massively complex simulations and in turn used in such diverse categories such as weather forecasting and astronomical projections, can also be shown to have a huge carbon footprint (Zwart, 2020). |
| **Blockchain** | This foundational technology has promised to revolutionize everything from digital currencies to supply chain infrastructure to (ahem) carbon market management; its dependence on various compute-heavy cryptological tasks make using specialized hardware farms and huge energy inputs necessary. To take Bitcoin, the granddaddy of blockchain applications as an example, total annual energy consumption has been estimated in the multi-terawatt hour levels, with a carbon footprint approaching the levels attained by sovereign countries (Christian Stoll, 2019). Indeed, Bitcoin and its ilk have been cited for high levels of energy consumption and concordant environmental impact. |
|  | **Various approaches have emerged towards mitigating these concerns.** |
| **Use renewable energy** | A number of companies have ramped up significantly on purchasing renewable energy; Google for instance started by buying 114 megawatts from an Iowa wind farm in 2010, to committing to 2.6 GW worth, enough to power all its global operations in 2017 (Hölzle, 2016). Amazon announced The Climate Pledge last year, in which Jeff Bezos outlined their goal to consume 80% of its total energy from renewable sources by 2024, 100% by 2030 (Calma, 2019). |
| **Reuse ambient energy** | Reducing the consumption of energy has also been at the forefront of efforts to mitigate climate concerns. For example, using cold environments as heat sinks saves not only on energy consumption but on cooling costs. Microsoft recently conducted experiments where it encased a number of servers in an enormous cylinder and placed it deep underwater to efficiently shed heat to its colder surroundings (Roach, 2020). This also had the added advantage of somewhat improving its performance and reliability due to its isolation from oxygen/humidity corrosion, temperature fluctuations, etc. |
| **Distribute compute load to target low impact sources** | Yet another approach to mitigating environmental concerns is to move computing workloads to hit low impact energy sources (Julia Lindberg, 2020). This can be done at the data center itself, using energy consumption data trends to model power consumption, calculate the energy load and carbon footprint of available data centers and ultimately move the processes to the compute centers best suited to the allowable environmental impact envelope (Patent No. US20100058350A1, 2008USA). |
| **Distribute hardware to reduce transmission effects** | Lastly, another approach is to move storage to low power consumption devices that are geographically localized to the users’ location, once again to limit transmission costs (Lorenzo Posani, 2019). This approach effectively decentralizes the data storage infrastructure, while still using the internet to communicate to a coordinator server for data coordination purposes. Main advantages cited are the energy saved in cooling massive numbers of data servers on hot racks, and the lower transmission energy costs given the data’s proximity to the consumer. Given one specific extrapolation scenario, total saved energy cited was around 0.67 TwH, equivalent to approximately 300,000 Mt CO2. |

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