A streaming-oriented approach to personal computing

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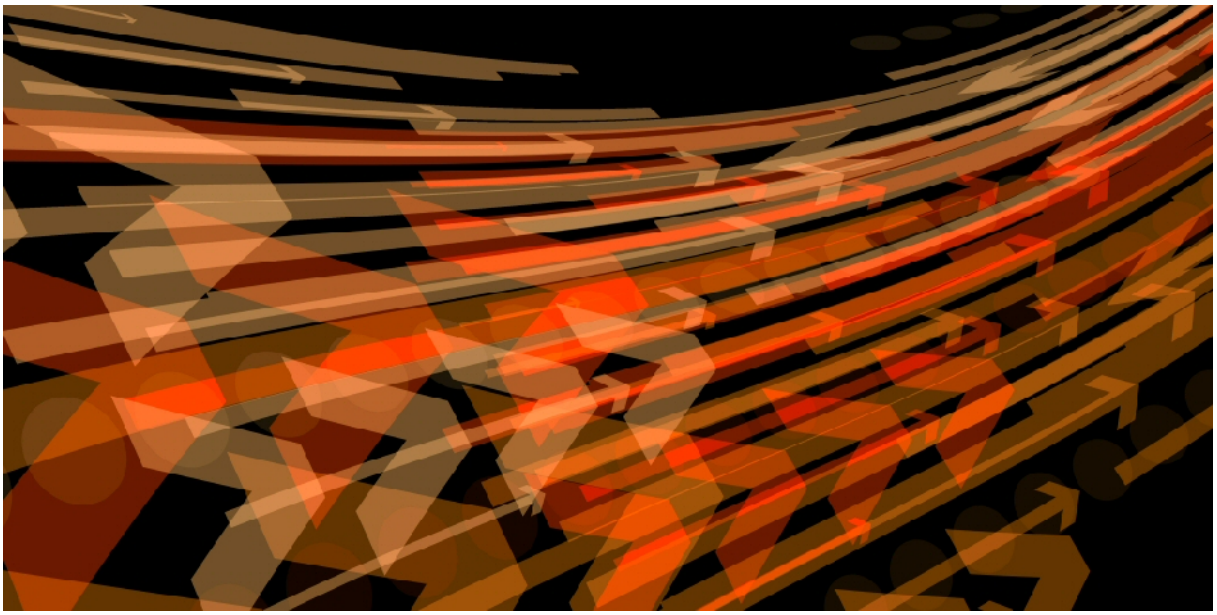

This is an edited-extract from my essay on Why Our Digital Future Needs Unlimited Data.

Today, we have a predominantly download-oriented approach to personal computing (what we do with our personal computing devices), in which we download large quantities of data, such as ebooks, movies, music, operating systems, pictures, software applications, and web pages, from the Internet that will then be processed (presented/played/run) on our local personal computing devices (desktops, laptops, smart-phones, tablets). To be fair, some types of digital content such as videos and music are also available by data-streaming, where a portion of the digital content, for example, a single frame of a movie, is consumed in real-time as it is received rather than after all the digital content, the whole movie, has been fully downloaded. One data-streaming service, Netflix, a video streaming service, is a leading source of Internet traffic in North America; such is the popularity of this particular service. Nevertheless, our world is still, on the whole, a download-oriented one.

This has been practical for two reasons, the first is the ever-increasing communications bandwidths supported by the Internet and the last-mile in particular, which have managed to keep pace with the phenomenal growth in downloaded data that has occurred over the last few years, and the second is because our personal computing devices have become highly-capable data-processors, which are then able to efficiently and effectively process all that downloaded data. It has also been wholly necessary, because in the past our telecommunications infrastructures were just not sufficient, in terms of affordability, availability, bandwidth, latency, and reliability, to allow us to

architect a large-scale personal computing approach that was significantly different to this. However, the telecommunications technologies that underpin our increasingly digitised world are rapidly nearing the point where a far more efficient and effective approach to personal computing can finally be adopted; a streaming-oriented approach. Next-generation telecommunications will allow, if we so wish, all of our required personal computing functionalities to be streamed from remotely-located cloud computing-based data centres, using real-time communications protocols, over the Internet.

However, a streaming-oriented approach to personal computing will require the consumption of very large quantities of data. In fact, it will require the consumption of far more data than even the most generous Internet Service Provider (ISP) or telco offers today, even on their top-of-the-range so called 'unlimited' data packages, and it is for this simple reason that limited data allowances (data caps) are very likely to become a source of conflict/disagreement/dissatisfaction/upset at some point in the future. In fact, unless ISPs and telcos are able to quickly transition to an 'effectively' unlimited data model (unmetered), our bright and shiny all-video-all-the-time science fiction future that is currently hovering just out of reach on the technological horizon may never be realised, and we will be stuck in our current technological cul-de-sac forever. The good news for ISPs and telcos is that overall communications bandwidth requirements would substantially reduce if we were to adopt a streaming-oriented approach to personal computing, because digital content & services would only need to be communicated at the speed-of-consumption instead of as-fast-as-possible, which is what is required to effectively support our current download-oriented approach to personal computing. The problem with as-fast-as-possible is that people are impatient and as-fast-as-possible never seems to be fast-enough. The speed-of-consumption, on the other hand, is always fast-enough, which makes it a much better foundation for the future of personal computing.

By permanently moving all of our data and all of our data processing to the cloud, only audio-visual representations would then need to be communicated over the Internet (in simple terms, think a bunch of pixels representing the page of a book rather than the actual words of the book rendered using HTML). Streamed services would include application streaming, cloud gaming, hosted desktops, music streaming, video conferencing, video streaming, voice over IP (VoIP) telephony, and web desktops, to name but a few. Such streamed services encompass nearly all the personal computing functionality that we currently perform locally. Our myriad personal computing devices would then be able to become simple, low-cost, long-lasting, audio-visual presentation terminals (thin/zero clients), that are just good-enough to receive data from the cloud, display video, play music, and send user-input to the cloud. Of course, this will only be possible if Internet connectivity becomes highly affordable, high bandwidth, low latency, highly reliable, and ubiquitously available, which should, believe it or not, start to happen in some parts of the world in the very near future. The other enabling technology is cloud computing, which is already proven and rapidly maturing.

Video, in all its different forms, would become the primary communication mechanism, and as the communications bandwidth requirements for streaming even high-definition video are really very modest, the cost of Internet access should, in theory at least, become greatly reduced. For example, using current-generation video codecs, such as

VP8 and H.264, Standard Definition (SD) video at 30 frames per second (FPS) requires a communications bandwidth of *approximately* 1.5 Mbps, Full High Definition (FHD) at 30 FPS video requires a bandwidth of *approximately* 6 Mbps, 4K Ultra High Definition (UHD) video at 30 FPS requires a bandwidth of *approximately* 24 Mbps, and 8K UHD video at 30 FPS requires a bandwidth of *approximately* 96 Mbps. Using next-generation video codecs, such as VP9, H.265, and Daala, bandwidth requirements can be halved.

Such bandwidth requirements seem almost trivial compared to the 20,000 Mbps (20 gigabits per second (Gbps)) last-mile bandwidths promised by Fifth-Generation Mobile Communications (5G), and which are due to start arriving in 2020. In fact, the adoption of a streaming-oriented approach to personal computing could potentially remove the need for such incredibly high last-mile bandwidths completely, or if not completely remove then greatly reduce. Of course, such thinking might seem controversial, even foolish given the established nature of the Internet, personal computing, and Web, but if so much can be achieved using last-mile bandwidths that are less than 100 Mbps do we really need to widely deploy 20 Gbps? Surely it would be much more helpful, for example, to channel our efforts towards improving the affordability, availability, latency, and reliability of Internet connectivity by a hundred fold than to increase bandwidths beyond all reasonable need. The ever-insatiable download-oriented approach to personal computing needs such bandwidths, and so much more, and always will, but a streaming-oriented approach does not. The bandwidth needs of a streaming-oriented approach to personal computing are orders of magnitude less, and actually have an easily achievable upper limit that is determined by the display resolution of our personal computing devices.

To balance the expected cost reduction for both personal computing devices and last-mile Internet connectivity, the use of subscription-based remote personal computing services is likely to substantially increase, with the result that a typical user would probably end up paying roughly the same as today, with less spent on devices and connectivity but more spent on remote personal computing services. Internet connectivity services would most likely continue to use a tiered-pricing model, in which more costs more, but instead of the pricing-tiers being based on the quantity of data that can be downloaded per month, the tiers would be based on levels of communications bandwidth. The different bandwidth levels would allow video to be consumed at different resolutions and frame rates; with higher bandwidths supporting higher video resolutions and frame rates than lower bandwidths. Under bandwidth-based pricing, it would then be possible to swap our current ‘limited monthly data allowances’ for 'effectively unlimited monthly data allowances’. That is to say, a customer would be able to use their Internet connection at the bandwidth level that they had purchased without any download or upload data cap for the equivalent of a specific number of hours (*for example*, 8, 16, or 24) per day, 7 days per week, and 31 days per month. Bandwidth-based Internet connectivity packages are also likely to include a limited quantity of data that can be communicated (uploaded or downloaded) at a higher-than-normal bandwidth, for use in situations where large data files need to be communicated as-fast-as-possible, although the use of such a feature would become increasingly rare as users become ever more accustomed to permanently storing all their data in the cloud, simply accessing it through audio-visual representations, as and when required.

Today, the quantity of data that would be required to support a streaming-oriented approach to personal computing seems *unimaginably* high, of the order of terabytes per month, when we can barely afford a hundredth of that over a wired Internet connection or a thousandth of that over a mobile Internet connection, but as the cost of the photons and electrons that we use to communicate becomes ever cheaper, it is an approach that will soon become very possible, perhaps even inevitable.