The energy cost of your Netflix habit

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ABSTRACT

Through measurements on our testbed, we show how users of Netflix could make energy savings of up to 34% by adjusting video quality settings. By using Netflix as a case study, we aim to assess the impact of energy usage in Video-on-demand (VoD) services. We estimate the potential impact of video quality settings on energy usage on a global scale.

1. INTRODUCTION

Video-on-Demand (VoD) is by far the most popular type of traffic on the Internet today (April 2015). The Sandvine Global Internet Phenomena report for H1/2014 [1], says VoD was responsible for 64% of all the downstream traffic experienced on fixed networks, and 40% on mobile networks in the US, with similarly large proportions experienced in other geographical regions. Cisco[2] estimates that by 2018, 79% of all Internet traffic in the world will be some form of video. Video consumes more resources – network capacity, device CPU utilisation, memory, I/O, disk space etc. – than the other Internet media, such as text, audio and still images. So, it follows that video also consumes more energy and has a larger carbon footprint than other application flows.

Netflix is the world's largest *premium* VoD service, available to over 50 million users in almost 50 countries. It is responsible for 34% of the downstream traffic in the US [1]. In August 2014, Plusnet, a major ISP in the UK, announced that Netflix had become the largest single source of traffic on their networks during peak hours.

2. EXPERIMENT METHODOLOGY

We performed an empirical investigation of the CPU, energy, and network bandwidth consumption of Netflix video playback on a desktop client system. Our focus was investigating the client side energy usage of video on desktops: globally, the energy usage at the client is at least the same as that of datacentres [3].

Using a simple testbed, we made measurements of system resource usage for over 200 unique video titles from Netflix UK. Users may select one of three preferred quality levels (LOW, MEDIUM and HIGH), or allow Netflix to automatically choose, as shown in Figure 1.

3. RESULTS

We captured the CPU utilisation, memory usage, network usage and power consumption at 1 second intervals during video playback. Figure 2 has summary results.

Previously, we defined an energy metric for video P_{dv} [4]:

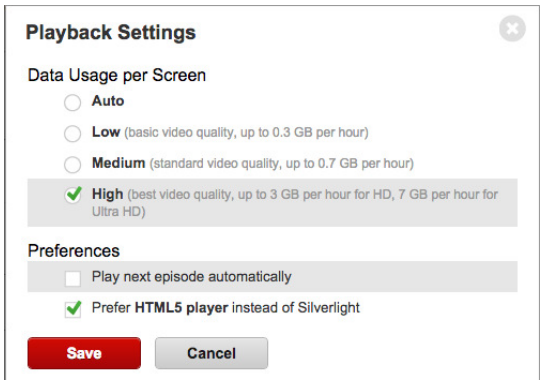


Figure 1: Netflix playback quality settings for selection by the user.

$$P_{dv} = \frac{\text{energy usage for video decoding/playback}}{t_v} = P_a - P_{idle} \quad (1)$$

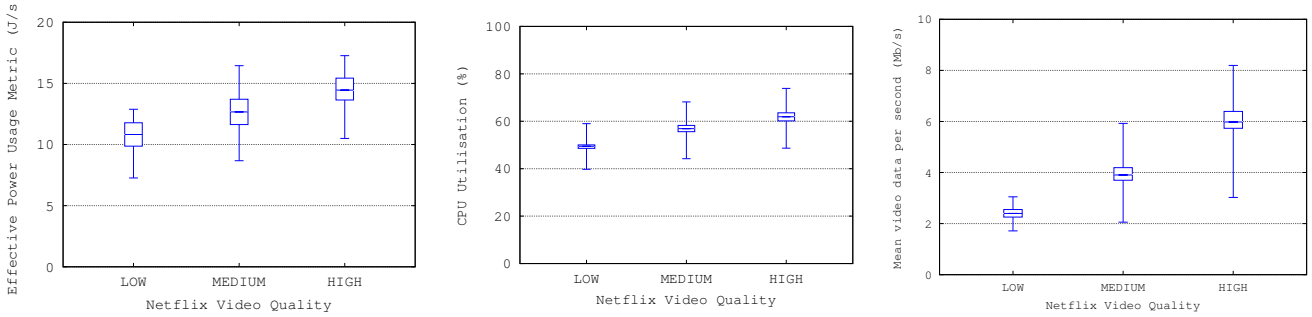
where P_{dv} is the mean energy usage per second of video decoding / playback, P_{dv} (units (J/s_v)), and t_v is the duration of the video stream in seconds. P_a is the mean measured power of the system during decoding (or encoding) of the video. P_{idle} is the mean power when the system is idle.

In Figure 2, each data point used for the boxplot is the mean of 5 runs from a 2-minute clip of video from the chosen video title. Figure 2a is energy usage as given by equation 1). We obtain average values of 10.8 J/s_v, 12.7 J/s_v and 14.5 J/s_v for the respective quality levels. This corresponds to a difference of 34% between LOW and HIGH quality levels. We observe significant variability in the energy and system resource usage over the entire corpus, even at the same quality levels.

We measured system resources (CPU and memory utilisation), with the Unix program *top*, and the network utilisation, with the program *tshark*. In Figure 2b and 2c, we show boxplots summarising the CPU utilisation and network bitrate for the entire corpus, grouped by Netflix quality level.

4. ENERGY SAVINGS AND TRADE-OFFS

A simple Fermi estimate based on our observations gives a view of energy usage by VoD at global scales, showing the significant cumulative impact from even small savings at individual client systems. Netflix claim they have over



(a) Mean power usage **(b) Mean CPU utilisation** **(c) Mean bitrate**

Figure 2: Summary of the resource usage (energy, CPU and network) for playback of the entire corpus of Netflix videos at the available quality levels. The corpus consisted of 202 videos. Each data point is the mean of 5 runs, each of 120 seconds in duration.

50 million subscribers, and Nielsen Research[1] suggests that roughly 60% (∼30 million) of Netflix subscribers watch via a personal computer. Netflix have further claimed that 2 billion hours of video are streamed from their servers every month. Assuming savings as we have measured of 3.7 J/s_v by watching all video at LOW quality instead of HIGH, this would be a total of ∼7.4 million KWh a month or 88.8 Million KWh a year. To appreciate the scale of these savings, 88.8 Million KWh is enough energy required to power 21,382 homes in the United Kingdom or 114,138 homes in India for a year (based on available estimates[2]).

Our Fermi estimate is not an authoritative or comprehensive estimate: we wish only to show the sheer scale of the energy savings potentially possible, and raise awareness of the amount of energy consumed by video streaming. Our assumptions that all users will see similar savings as our testbed and chose lower quality will not hold generally – some equipment may have greater energy usage, some may have less; while users may chose different quality levels based on personal preferences and costs. There are several other VoD services which have very significant numbers of users and viewing hours, so our numbers are likely to be an underestimate of the true overall impact of VoD.

Users need to be informed of energy usage and incenitivised to make energy-efficient choices, an issue of ongoing research in the wider community. In Figure 3, we propose a modification to the Netflix user interface of Figure 1.

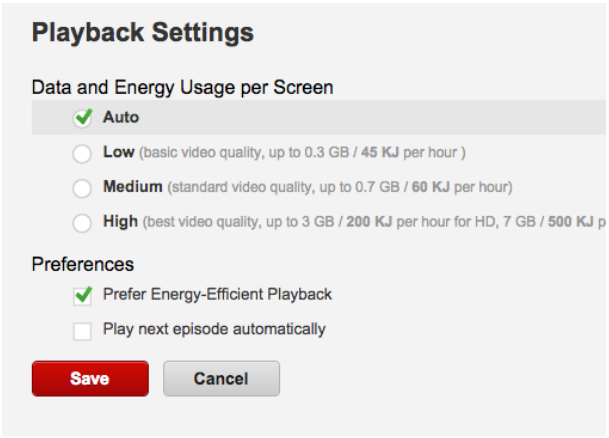


Figure 3: A mock-up of modified Netflix quality selection page with very simple energy usage information. This information could be based on a system specific benchmark or crowdsourced usage data.

5. CONCLUSION AND FUTURE WORK

Small energy savings on video playback for a single client can sum to significant energy savings when considered for a global population of users. Our experiments and estimates show there is the potential to save many millions of KWh of energy is users can be incentivised to make appropriate choices in video streaming.

Items for future work include: finer-grained analyses of the energy usage of video playback across genres / spatio-temporal classification; studies on mobile and other devices (e.g Smart TVs); exploring green quality of experience (QoE) metrics and energy usage feedback for video; and incentives for saving energy while using digital video. A benchmark tool for video energy usage, based partly on the work presented here is currently under development [5].

[1]http://www.nielsen.com

[2]http://www.wec-indicators.enerdata.eu/household-electricity-use.html

Acknowledgements

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6. REFERENCES

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