Comparative analysis of overall energy consumption of storage architectures in home media players

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Nowadays, people spend more time on entertainment compared to the past. Because of the fast and easy access, anyone can have entertainment almost anywhere. For example, we can hear music or watch videos even when we are walking. Currently, there are many options for multimedia gadgets such as mp3 players, CD players, mp4 players, radio player, portable game sets, etc. Even after we go back to our homes, we still prefer to have entertainment as a way to relax for example watching the newest movies. Because of that, the multimedia data is becoming important asset in our daily lives. The more we can have it, the better. For storing the multimedia data, people prefer big capacity of storage as the main component of the media player, particularly in home media player. However, before choosing which storage architecture to use, we need to consider the important factors like the running cost, noise, heat, and energy consumption from it.

For home media players, Home Theater PC (HTPC) is a good choice since it can provide high quality video output and is affordable in term of cost. For setting up an HTPC, people usually use their old PC and customized it to provide good quality of media playback. When connected to other devices like display and speakers, it can provide high quality of movie playback with nice sounds. Another reason is that it is easier to

upgrade to match any development that occurs. It is different with other dedicated service gadgets, which are more difficult to upgrade. In most cases, we need to replace the old ones with the new ones. Beside that, we can customized it to provide more functionality according to our needs like internet connection, radio or games since it is basically a PC machine.

However, in home entertainment, reducing energy is highly desirable. In our research, we investigated the overall energy consumption of storage architectures in systems built around a HTPC. There are several architecture choices that could potentially play a significant role on total energy consumption. In particular, we identify three choices:

- **HDD vs. SSD**: HDD can provide bigger capacity with affordable price. Even though, SSD is much more expensive, it is better in speed performance with less energy consumption compared to HDD. In term of energy consumption, is it true in all cases?

- **Local Storage vs. Network-Attached Storage (NAS)**: Local storage might be better in media playback performance and energy efficiency compared to NAS. However, NAS can provide benefits like centralized data storage and no extra space wasted for duplicate files.

- **Prefetching**: Typical Home theater PC might have big size of system memory installed for the cheap price of RAM memory. It is an opportunity for energy savings by applying *aggressive prefetching* to extend the disk idle time for saving energy.

Each storage architecture option offers different pros and cons. For having big storage capacity, people will intuitively choose HDD as the storage because it is much cheaper in term of hardware price. Choosing HDD might be an attractive option but it consumes much more energy compared to the other storage option, SSD. Because SSD is a NAND-based flash storage, it does not have any mechanic part like HDD to store the data. That is why SSD consumes much less energy if we compared to HDD. However, it is all based on people's intuitive consideration. In this research, we want to investigate the energy consumption of using different storage architecture during the movie playback in home media player. The other storage option we consider in this research is Network-Attached Storage (NAS). It has the

advantages that local storage do not offer like the centralized data storage and no duplicate movie files exist which means saved space.

We evaluated experimentally three different storage architectures by measuring important aspects, namely, energy consumption as the main metric. Besides, we also evaluate the hardware cost, playback performance, and maintenance effort of using the storage architecture in HTPC.

To do so, we have built and instrumented a benchmark environment, as well as a microcontroller-based device to monitor and record energy consumption directly from power cables. For the benchmark environment, we have the setups like a HTPC machine, local storage (HDD and SSD), and a unit of NAS server. For measuring the power consumption of the storage, we have developed a measurement device. The device was built by using Arduino as the microcontroller and two pieces of current sensor. The microcontroller will get the current values passed from the sensors and record all the data into files in a MicroSD card. In the experiment, we have tried to run and calibrate the device to provide accurate results.

We considered important key factors like the characteristics of storage medium, system memory size, prefetching size as well as the workload parameters like the size of multimedia data, duration of playback and also application parameters of the system application to explore the possibility of better energy efficiency and performance.

Before starting the experiments, we studied on the details of the system and listed out the possibilities that can be explored by making a plan with systematic approach as the initial study. We repeated the experiments of each scenario to be able to observe the variances.

We presented the comparative analysis of energy consumption of the storage architectures based on the data from the experiments. Interestingly, we have found that by applying aggressive prefetching, the energy consumption of HDD can be reduced to the same levels as SSD for video playback. This means that, with appropriate system support in the media player, SSD is not yet ready to replace HDD, even on the ground of energy-efficiency. For NAS, we found another interesting result that using HDD as local storage will consume less energy compared to using SSD. Based on the analysis of the experimental results, we identified the energy and cost efficient storage architectures in home media players.