

## Energy measurement for mobile phone's data compression and transmission

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**Abstract.** Cloud service has been widely used in people daily life for its convenience and security. In general, there are two sub processes in the course of the interaction mobile devices and cloud servers: data compression and transmission. In this paper, we present a test methodology for evaluating energy cost on mobile devices, and propose a power module for analyzing the energy consumption during data compression and transmission. We propose an energy cost model for data compression and transmission to describe the energy consumption during the interaction process. Then we apply the energy measurement methodology to the experiment for different data compression and data transmission methods, and find an energy efficient data compression method for these two sub processes.

### Introduction

The Cloud Service brings great convenience to our live, meanwhile, it's also a great challenge for the battery life. The compression and transmission, the main operating in interacting with the clouds, are both inefficient. In addition, recent data shows that the compute capability and transmission rate on smartphones are rapidly increasing in recent years, whereas the battery industry moves forward slowly (battery capacity grows by only 5% annually) equation reference goes here [1]. So designing energy-saving interacting application is becoming a hot topic, but many software designers have limited experience with the energy-constrained devices [2].

Most of applications on cloud storage only consider the convenience they bring to life, and the energy consumption is not in their consideration. Application developers' only indicator is the performance, while our goal is to select the most energy-efficient compression tool. From an application developer's perspective, this simplifies the selection between the multiple existing compression tools. From a mobile user's perspective, this allows the system to optimize the battery life by using the energy-efficient compression tool and transmitting the compressed file, which reaches the same function with less energy. This is beneficial for smartphones that extends the standby time. It extends the battery life, thus greatly improves the user experience [3].

Because of integrating with a variety of hardware, the power consumption of smartphone is extremely complicated. Perrucci [4] measures the power consumption of Wi-Fi, Bluetooth, Cellular and miscellaneous and derived a set of simple power model. Abdelmotalib [5] measures the power consumption of CPU and Memory on different mobile devices. Balasubramanian [6] propose a detail measurement methodology of Wi-Fi, 3G and GSM of smartphones.

To extend the standby of smartphone, we need to know the difference between the individual energy consumption caused by different compression tools. According to the above consideration, the power consumption will be divided into two parts, the compression and transmission. So we have to measure the energy consumption of the two sub-progress, respectively. A test methodology is presented before the measurement to reduce the number of test cases. After getting the testing results, we propose efficiency value to judge the compression tools. From which we can get most energy efficient tool to deal with the data including compression and transmission. We also test our methodology on another smartphone to verify our result. Specifically, we make the following contributions: (1) we present a rigorous methodology, which obviously reduces the number of test

cases. We also explains the independence between parameters on the smartphone. With the methodology, the total number of test case can be reduce to a desirable value, which is close to dozens. (2) We present Efficiency value to evaluate each compression tool, from which we can easily select out the most energy-efficient compression tool. The value is calculated by a function which is only related to the size of input file and the compression tool.

## Power Model

In this section, we first propose the power model for interaction process, then present efficiency value for evaluating the whole process consisting of compression and transmission. Four compression tools, zip, Gzip, zlib and 7z, are tested in our experiment, we propose efficiency value to evaluate their energy cost. Firstly, we divide the whole process into two parts, the compression and transmission, then calculate their power consumption respectively.

As is known to all, the power consumption can be expressed as the formula:

$$W = U \times I \times T. \quad (1)$$

For smartphone, the voltage  $U$  is constant whose value is  $3.7V$ . And the current  $I$  can be measured by out laboratory instrument called Power Monitor [4]. The key is to calculate the time  $T$ . In this Sub-process,  $T$  refers to the time of compression. Obviously, it is dependent on the size of input file and the compression tool. According to the methodology proposed in previous section, we only select one size to take experiment, we do a large number of tests to explore the relationship between the time and size of input file. According to the experimental results, we find that the compression time has a linear relation with the size of the input file  $s_{in}$ . Then time  $T$  can be represented as  $T_c(s_{in})$  and the power consumption can be expressed as  $W_c = 3.7V \times I \times T_c(s_{in})$ .

In the transmission sub-process,  $T$  refers to the time that transmitting the compressed file to the server costs, which is depend on the transmission rate and the size of transmission file. Since the file transmitted is generated by the compressing the input file, we use  $s_{comp}$  to express it. Then it can be expressed as  $s_{comp} = s_{in} \times R$ , where  $R$  means the compression ratio. With the transmission rate  $v$ , the power consumption of this sub-process is  $W_t = 3.7V \times I \times (s_{comp}/v)$ .

Based on these two sub-process, power cost of the entire process can be calculated as the sum of them. In order to evaluate the four compression tools more directly, we propose a new concept called Compression Efficiency Value, and its unit is  $m$  J/KB. From which, we can get the power consumption in dealing including compression and transmission with per 1 KB. This allows us to judge the quality of the tool more directly. The value is computed using Eq. 2.

$$E(k) = (W_c + W_t)/s_{in}, \quad (2)$$

where  $k$  means the compression tool. We number for each compression tool, and the range is from 1 to 4.

## Experiment

In this section, we first describe the experiment setup for power measurement, then the detailed experiments we have conducted will be introduced.

As we mentioned before the process is divided into two sub-processes, the Compression and transmission. Based on the selected parameters, we measure the power consumption for the two sub-processes respectively. In our experiments, we use the following devices: a Monsoon power monitor, for power measurement, a Samsung I9100 with Android 4.0.3, and a PC. The power monitor supplies a stable voltage to the phone instead of the Lithium battery and samples the power consumption at the rate of 5KHz, it is connected to the PC by USB for data collection. We implement

the control program on Samsung I9100. I9100 provides Exyons 4210 CPU which max rated frequency is 1228 MHz. We install the power tool in the PC. Then we develop an application, through which we can set all the parameters on the smartphone. It can set the frequency the smartphone works and the transmission speed, all the parameters will have a great influence on the power consumption. And the application runs under the condition of locking the screen, which would reduce the impact of other application and hardware.

Based on the compression time and the current, we get the power consumption shown in Fig. 1. In the diagram, we can see the zip is the most energy efficient compression tool and the 7z the most power-hungry in the four compression tools. And for the same compression tool, when the CPU works at 500MHz or 800MHz the compression sub-process is the more energy efficient.

Based on the average current and the transmission time, we can get the power consumption of the transmission sub-process shown in Fig. 2. From that, we can clearly see that the larger the transmission rate is, the less power consumption of the whole sub-process costs at the same frequency. For the same rate, the high frequency leads to the high power consumption, however, as the speed increases, the gap between them reduces.

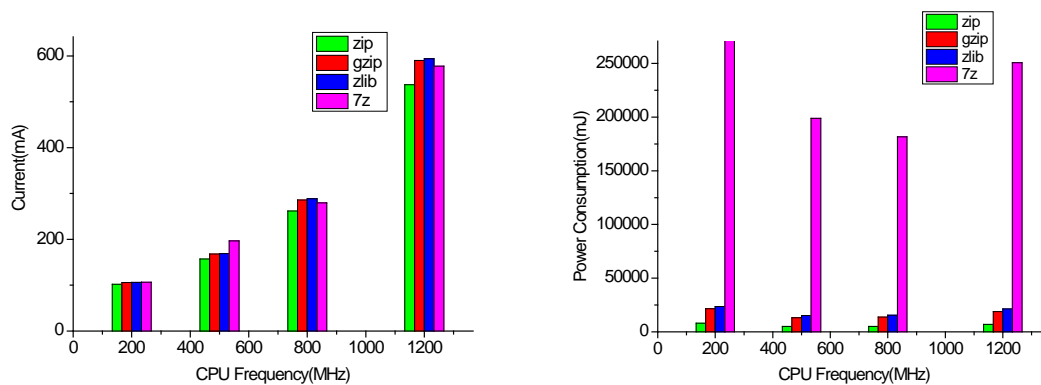


Fig. 1 Current and power consumption of compression

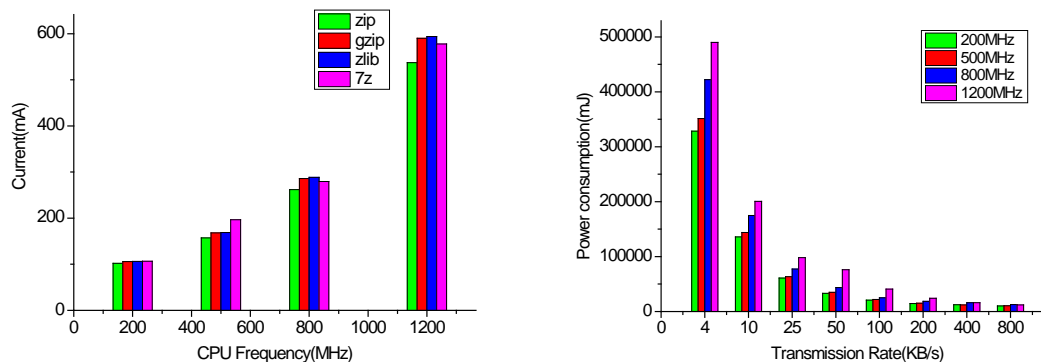


Fig. 2 Current and power consumption of compression

After measuring the power consumption of the two sub-process, we measure the power consumption of the whole interaction process. In this experiment, we not only record the power consumption which can get through the Power Monitor, we also calculate the consumption using the consumption models we have constructed. Then we will compare the two power consumption to evaluate the accuracy of the model we created in the previous experiments. Finally, we will use the Efficiency Value to evaluate the four compression tools and select out the most energy-efficient compression tool.

First we can see only one compression tool will be more energy electricity than direct transmission, and the zip is the most efficient compression tool at any frequency. With CPU frequency increases, the power consumption will be increased, but the effect of energy saving will be more obvious by using compression tools. In addition, there are other two factors directly affect the Efficiency Value,

the file size and transmission rate. Fig. 10 shows the details of the most efficient tool transferring at all the transmission rates.

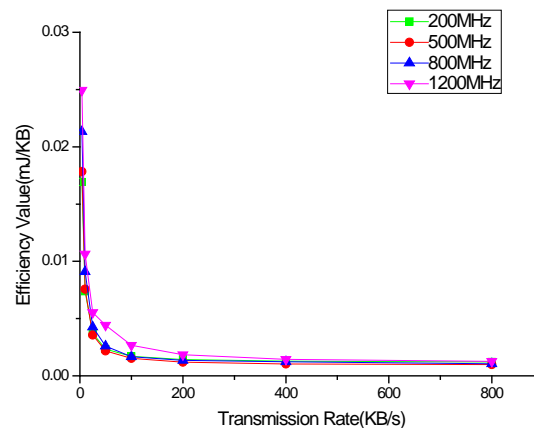


Fig. 3. Efficiency Values of Zip

We find that the smartphone cost higher power with higher frequency. But with the increasing of the transmission rate, the gap between them is narrowing. When the transmission rate is to 800 KB/S, the four efficient values of zip are almost equal. This conclusion will bring great convenience for android developers when they select compression tool. And for one compression tool, we also can select a frequency to accomplish the compression and transmission of high efficiency and power saving.

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