Battery Life | Automatic Measurement System | Base Station Simulator

Technology Reports

Automatic Measurement System for Smartphone Power Consumption in Mobile Environments —Improving the Battery Life Measurement Environment for Smartphones—

In response to complaints from smartphone users about excessive power consumption, NTT DOCOMO has released information on smartphone battery life in terms of an index called "actual usage time." However, the results of measuring power consumption in a mobile environment, which is one evaluation item for determining actual usage time, can be influenced by various factors such as traffic jams and changes in the measurement area such as the addition of more base stations. This creates a problem in measurement reproducibility, which affects the reliability of this index. NTT DOCOMO has been working to systematize the measurement of actual usage time and has developed an automatic measurement system for smartphone power consumption featuring high reproducibility and automatic testing.

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1. Introduction

Battery life is one feature that users consider in selecting a smartphone. At NTT DOCOMO, we have established an index called "actual usage time" for evaluating the battery life of handset models by a uniform standard. We determine actual usage time by modeling and assessing usage conditions that can be envisioned for general users, and in this sense, it is a quantitative index that approximates what users actually experience.

At the same time, the mobile environment can be defined as one type of usage condition for evaluating power consumption while the user is moving, but measurement results in this environment can be influenced by various factors such as traffic jams and changes in the measurement area environment such as the addition of new base stations or implementation of measures for improving radio communication quality. This makes measurement reproducibility low and the cost of measurement high. In response to these issues, we have developed a system that can simulate the mobile environment to measure power consumption and have enabled this system to perform automatic measurements. With this system, we have enhanced the reliability of actual usage time while lowering measurement costs.

In this article, we describe this system

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for automatically measuring smartphone power consumption.

2. Overview of Actual Usage Time and Associated Issues

2.1 Definition

At NTT DOCOMO, we assume a total smartphone usage time per day of approximately 85 minutes that includes time spent browsing the Web and using Social Networking Services (SNS) and other applications, and we define battery life under such conditions as "actual usage time." The value that we obtain in this way is released as one item in the specifications listed for each smartphone [1].

2.2 Measurement Conditions

Measurement conditions for evaluating power consumption can be broadly divided into a smartphone usage state (in which the user is performing smartphone operations) and a standby state (in which the smartphone is stationary or mobile). In the standby state, we consider that power can be consumed by mobility control*1 (handover*2, cell search, etc.) in radio communications while the smartphone is moving, so we divide this state into two patterns consisting of a stationary environment and a mobile environment.

At NTT DOCOMO, power consumption is measured in each of the states shown in **Figure 1** under actual field conditions to match the user's usage environment.

2.3 Current Issues

The method that we have been using to measure power consumption in the mobile environment is to mount a smartphone on an automobile and drive along a public road. In this case, however, transmit/receive power in radio communications can vary due to traffic jams, weather conditions, and changes in the measurement area due to the addition of new base stations and other factors. This can affect the overall power consumption of the smartphone creating a problem in measurement reproducibility, and as a result, it has been necessary to perform multiple test runs.

3. Overview of Automatic Measurement System for Smartphone Power Consumption

To resolve the reproducibility issue described above, NTT DOCOMO developed an automatic measurement system for smartphone power consumption. We

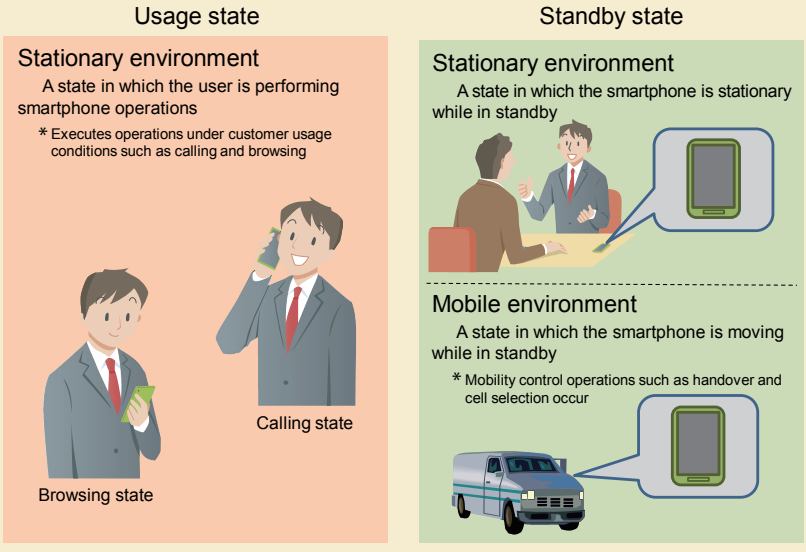


Figure 1 Measurement conditions for actual usage time

*1 **Mobility control:** A control function that enables the continuous provision of incoming and outgoing communications for moving smartphones.
*2 **Handover:** The process of switching the base station connected to the UE.

describe this system below.

3.1 System Configuration

System configuration is shown in **Figure 2**. To achieve high reproducibility in measurements and improve measurement efficiency, this system adopts a base station simulator that can interactively respond to communication requests and packet transfers from a smartphone. In this system, the base station simulator simulates radio communication quality while the smartphone is moving and the current measurement equipment measures the power consumed by the smartphone during base station simulator operations. Each of these pieces of equipment can be controlled by a single Personal Computer (PC). Furthermore, with the aim of automating the control of measurement equipment, we have enabled measurements to be executed without human intervention with the exception of initiating and terminating measurements.

3.2 System Operation

In this system, we incorporated functions that focus on concerns about effects on smartphone power consumption and performed the following tests when constructing the system.

1) Variance in Radio Communication Quality

It is known that power consumption differs according to the radio communication environment in which the smartphone is located. An environment with poor radio communication quality forces transmit power to be increased and is therefore one factor in increasing power consumption. In an actual environment (in the field), radio quality differs from one measurement to the next due to traffic and weather conditions in addition to the traffic lane used while driving, surrounding vehicles, etc. As a result, variance arises in measurement results making it necessary to assess the validity of the results obtained after making multiple measurements.

We have verified that the system that we have developed can obtain test results equivalent to those in the field by creating a model for average radio quality when performing multiple measurements in the field.

2) Cell Switching

In a mobile environment, a smartphone switches cells so that good radio quality can be consistently obtained with the base station. As a result, cell switching occurs frequency while a smartphone is

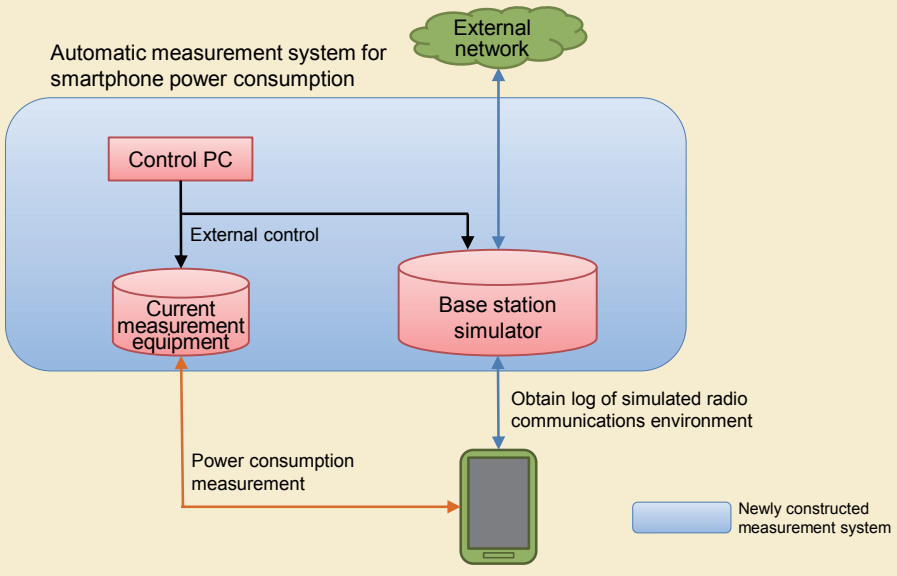


Figure 2 Configuration of automatic measurement system for smartphone power consumption

mobile, but this has the effect of increasing smartphone power consumption.

To reproduce cell switching in this system, we resolved the issue described below taking the cost of system construction into account.

- Simulation of multiple cells

  Increasing the number of cells to be simulated increases costs as more space and equipment become necessary. For this reason, the base station simulator in the existing system can only simulate up to two cells simultaneously. This means that continuous cell switching among three or more different types of cells cannot be executed directly on this system.

  To resolve this issue, we adopt the process shown in **Figure 3** instead of preparing multiple cells simultaneously. In this process, receive levels are varied in the manner of RF1-receive → RF1, RF2-receive → RF2-receive → RF1, RF2-receive → RF1-receive and so on, so that the parameters of the cell whose signals are not being received by the smartphone are continuously being changed to affect cell switching. This scheme creates an environment that simulates switching among different cells the same as in the field.

- Cell switching time

  The power consumed by a smartphone in a cell switching operation depends on the time needed to perform that operation. This system makes the time required for communications between the smartphone and base station simulator (response speed) the same as that in the field thereby making the power consumed by the smartphone compatible with that in the field.

  Additionally, as cell switching in the field comes in various types (such as moving between cells with a different radio frequency), we surveyed whether that would have any effect from the viewpoint of power consumption and made the system fit with actual field conditions as needed.

3.3 System Measurements Results

An example of measurement results in the field is shown in **Figure 4**. These measurements of smartphone power consumption were obtained on a driving course designated by NTT DOCOMO. They show that power was consumed by a variety of smartphone operations while driving on that course. In such measurements, the average power consumption is taken to be the final measurement result, but since measurements in the field exhibit large variance, it has been necessary up to now to obtain multiple samples and adopt the average value of those samples.

Results for smartphone power consumption obtained by this system are

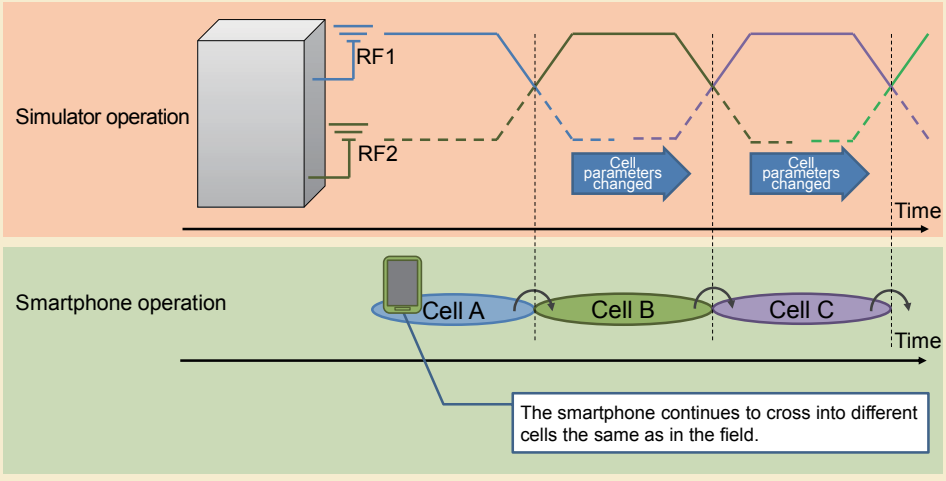


Figure 3 Virtual reproduction of multiple cells

compared with those obtained by field measurements in **Figure 5**. The measurement results for this system are presented as average values of power consumption using a pseudo-driving model and those for the field are presented as average values of power consumption obtained while moving. Examining these results, it can be seen that measurement results from the field exhibit large variance owing to a short measurement time because of cost considerations and to the

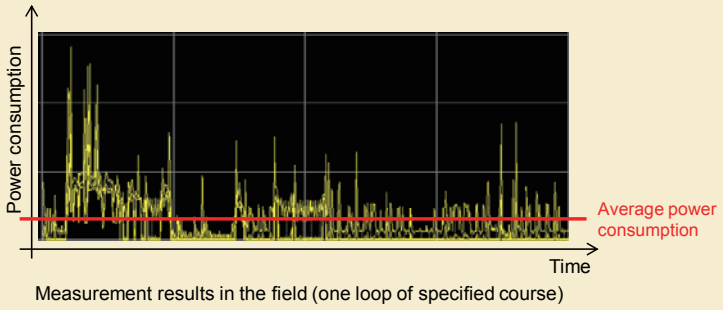
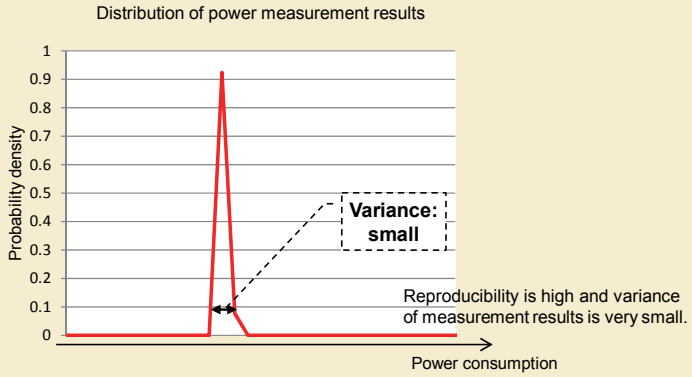
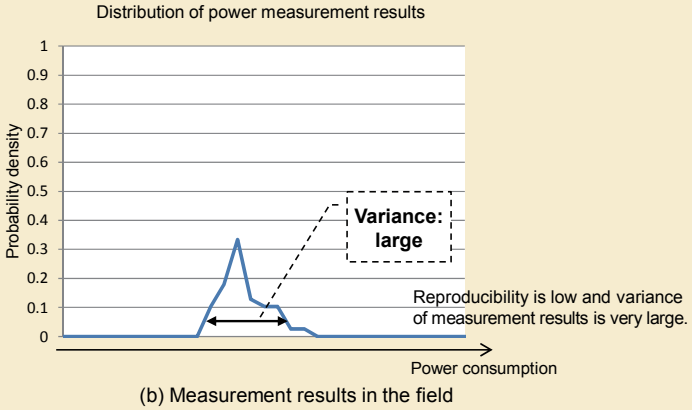


Figure 4 Actual example of smartphone power consumption



(a) Measurement results of automatic measurement system



(b) Measurement results in the field

Figure 5 Comparison of results between automatic measurement system and measurements in the field

effects of external disturbances. On the other hand, it can be seen that this system could minimize variance in measurement results by using a relatively long measurement time and reducing the effects of changes in the measurement area environment, traffic jams, etc.

4. Conclusion

At a time in which the number of smartphone users continues to increase, battery life is one item that is directly connected to customer satisfaction. NTT DOCOMO is working to improve battery life through various schemes and evaluation methods for testing the effectiveness of those schemes are essential.

The system introduced here features high measurement reproducibility and a low-cost approach to making mobile-environment measurements of actual usage time, but at NTT DOCOMO, we are also studying ways of automating the measurement of other items and of making further improvements to the measurement environment.

In addition, while this system was developed in the form of equipment for automatically measuring smartphone power consumption in a mobile environment, it can also be used to pretest the effects of changing radio network parameters on power consumption. In short, by incorporating a variety of parameter settings and cell arrangements, this system can be used to evaluate beforehand parameters in future NTT DOCOMO operation plans from the viewpoint of smartphone power consumption.

Reference

[1] NTT DOCOMO: "Simulation of Smartphone/Tablet Actual Usage Time" (in Japanese). https://www.nttdocomo.co.jp/product/battery_life/