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Dynamic adjustment of power consumption based on a time or event goal

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ABSTRACT

Users of mobile devices often experience a scenario where the available battery power is low, while a user activity is ongoing. Currently, users take actions such as reducing display brightness, turning off connectivity options, etc. to conserve battery power. However, such actions may not ensure that enough battery power is available to complete the user activity. This disclosure describes techniques to selectively enable smartphone power-saving features to achieve a user activity goal, or a desired amount of operating time to remain. The techniques can be enabled by a user of the device, or with user permission, can be enabled automatically. A power consumption model that provides a prediction of device power consumption is utilized to selectively enable power-saving features to meet the specified goal.

KEYWORDS

- Battery conservation
- Battery savings
- Battery prediction
- Power consumption model
- Smartphone battery
- Mobile operating system
- Power management

BACKGROUND

Users often experience that their mobile devices, e.g., smartphones, run out of battery at inopportune times. For example, a smartphone may run out of battery in the middle of

navigation, before the end of a phone call, before a wake-up alarm is activated, during movie playback, etc.

Users employ a variety of manual actions in efforts to reduce device power consumption. For example, users may turn off Wi-Fi or Bluetooth, reduce screen brightness, turn off mobile data, disable certain applications from using data, or toggle on/off a low power mode that performs a combination of power saving activities. Such attempts to reduce battery consumption can help users avoid running out of device power during important activities. However, mobile devices do not provide any guidance to users on which of these actions are suitable to preserve a given amount of battery power, with respect to a goal, e.g., completion of movie playback.

Current mobile operating systems warn users when user devices hit a certain threshold of low battery availability. For example, a smartphone may provide an alert to users when the available battery reaches 10% or 20% of total capacity. Users are prompted to enable a low power mode. However, such activation of a power-saving mode may not be enough to ensure that enough battery capacity is available to complete an activity that is important to the user, e.g., navigating to a destination. Further, no indication is provided to users on whether enough power is available to complete the activity. Users need to proactively plan battery usage to ensure that enough power is available to complete the activity using the device.

DESCRIPTION

This disclosure describes techniques to dynamically adjust power consumption of a mobile device, e.g., a smartphone, wearable device, tablet device, laptop, etc. to allow for battery consumption to be managed such that enough power is available to complete a user's time or event goal. The power consumption and usage is dynamically adjusted toward a time or event goal.

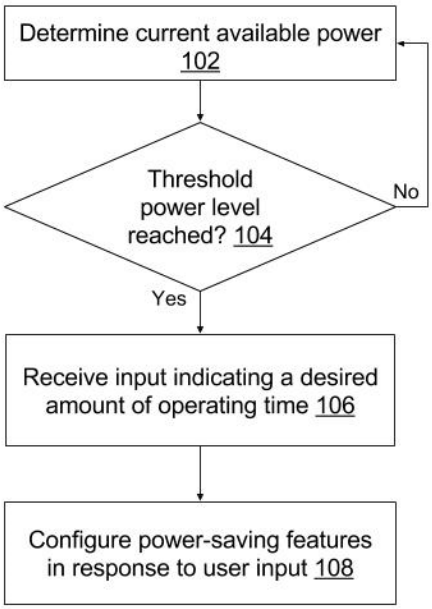

Fig. 1: Dynamic adjustment of power consumption based on time or event goals

Fig. 1 illustrates the technique of dynamically adjusting power consumption based on a user's input that indicates the amount of smartphone operating time to remain.

The current available power is determined (102). It is then determined whether a threshold level of power remaining has been reached (104). For example, the threshold can be selected a suitable power level, e.g., 30%, 25%, 20%, etc. If the device is determined to not have reached a threshold level of power remaining, no action is taken. If the device has reached the threshold level of power remaining, the user is prompted to indicate an amount of operating time needed to complete a time or event goal (106). For example, the user can input three hours, two hours, one hour, etc. or the user may simply input an event, such as "until my next alarm," "until the end of the movie," or "until I finish navigating home."

In response to the user input, power-saving features (108) are enabled and dynamically adjusted such that the user-specified goal is met with the available power. For example, such actions include dynamically dimming the screen, reducing clock speed of the device processor,

disabling Wi-Fi or mobile data connectivity, etc. to meet the required time or event goal for the smartphone to remain operational.

Alternatively, the dynamic power-saving adjustments can be enabled automatically based on determining a user goal, when users permit access to such user activity data and provide permission for such automatic enablement. For example, the device can automatically enable dynamic power-saving mode, e.g., when the user sets an alarm, to ensure that the device has enough battery to ring the alarm; begins to play a media file or playlist, to ensure that the device has enough battery to complete playback of the media file or playlist; begins navigation to a destination using a maps application, to ensure that the device has enough battery to complete navigation to the destination.

As some power-saving features conserve more power than others, and as power-saving features have a corresponding impact on the smartphone's performance, precisely which power-saving features are enabled is determined based on a model.

Mobile devices include a substantial amount of data about historic energy consumption. When users permit access to such data, a model is developed to determine the amount of energy needed to manage battery consumption to ensure completion of the user activity or goal. For example, the model may be a simple heuristic model that compares device usage (if permitted by the user) with corresponding power consumption during one or more recent time windows. The model can then extrapolate the determined rate of power consumption and determine the amount of battery available. If the rate of power consumption and available amount of battery indicates that the device will likely fall short of the user-specified goal, one or more of a set of power-saving features are enabled to compensate for the deficit in remaining power.

A more complex model can also be deployed, e.g., a machine-learning model. The machine learning model is trained to provide accurate forecasts of power consumption and available time for a device based on data of usage patterns for the specific device and other similar devices. The data on usage patterns is obtained and used only upon user permission for such use. The model can also estimate the impact of individual power-saving actions (or combinations of actions) on the specific device and on other similar devices, and choose the appropriate actions to meet the user goal.

The determination of available power and activation of power-saving actions is performed periodically. In the case of a simple model, the device is configured to perform a simple comparison of power consumption over a prior period (e.g., the last N seconds) against the allowable power consumption to meet the operating time goal. Based on the comparison, one or more power-saving measures are enabled or adjusted.

For example, consider a device has a power-saving mode enabled at 11 p.m., with 15% power remaining and a goal for the device battery to last until midnight. Thus, the device needs to be configured to not consume more than 0.33% of total battery power in one minute. With the techniques described, the device is configured to check its battery usage at 11:01 p.m. For example, it is determined that the device has used 0.5% battery after 1 minute elapsed versus the target rate of 0.33% per minute. In response, power-saving features are enabled or adjusted, e.g., using the model, to reduce power consumption to within the target rate.

In the case of a more sophisticated machine learning model, the device makes a request to a machine learning model, either one that is run locally on the device, or via a server, to predict the amount of remaining battery life. The model may make multiple predictions of the amount of remaining battery life. For example, the model may make one prediction of remaining battery

life if no changes are made, and additional predictions if various power saving features are enabled. The system may then compare the predicted amount of time remaining against the amount of time required to complete the task. If the amount of time required to complete the task is more than the amount of time remaining, the system may enable one or more of the power-saving features that are estimated to reduce power consumption sufficiently so that remaining battery time is at least equal to the time required to complete the task.

The techniques of this disclosure enable battery-powered devices to automatically manage power consumptions to meet an operating time or event goal, and can ensure that the device does not run out of battery power at inopportune times. The techniques can be integrated into device operating systems, or can be provided as power management software. Manufacturers of mobile devices, and carriers that provide wireless services can utilize the technology.

Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs or features described herein may enable collection of user information (e.g., information about a user's social network, social actions or activities, profession, a user's preferences, or a user's current location), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user, or a user's geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure describes techniques to selectively enable smartphone power-saving features to achieve a user activity goal, or a desired amount of operating time to remain. The techniques can be enabled by a user of the device, or with user permission, can be enabled automatically. A power consumption model that provides a prediction of device power consumption is utilized to selectively enable power-saving features to meet the specified goal.