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Enabling an Energy-Saving Mode on a Mobile Device After an Unexpected Charging Interruption

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Abstract:

This publication describes methods of enabling an energy-saving mode on a mobile device after an unexpected charging interruption. The power manager application implemented on the mobile device uses sensor data from sensors on the device and/or power quality data to determine if the charging interruption was expected. If the sensor data and/or power quality data indicates that the charging interruption was unexpected, the power manager application may automatically enable an energy-saving mode on the mobile device to conserve battery life. The user may also receive a notification from the mobile device that the energy-saver mode was enabled.

Keywords:

Mobile device, smartphone, battery saver mode, hibernation, standby mode, low-power mode, power saver mode, energy-saving mode, charging interruption, charging disruption, power outage, power failure, notification, automatic

Background:

Mobile devices (*e.g.*, smartphones) are frequently powered by rechargeable batteries. Rechargeable batteries have a battery life that represents the amount of time that the mobile device can be operated and used before the battery needs to be recharged. Charging a smartphone using a charger (*e.g.,* charging cable with a power source; wireless charging station with power source) can take several hours. If the power supplied to the smartphone by the charger is interrupted, the smartphone may not fully charge. It can be frustrating to the owner of the smartphone if their

smartphone does not fully charge, potentially limiting the function and use of the smartphone until a full charge can be acquired.

Smartphones are commonly equipped with an energy-saving mode (*e.g.*, battery saver mode). An energy-saving mode is a setting or mode on the smartphone that conserves battery life by, for example, limiting notifications, reducing screen brightness, decreasing background refreshes, or powering-down the smartphone. An energy-saving mode may include a hibernation mode where the smartphone remains asleep with no notifications or background refreshes until the user interacts with the device.

Description:

This publication describes methods of enabling an energy-saving mode on a mobile device after an unexpected charging interruption. The term "mobile device," as used in this disclosure, refers to a portable device that has both computational and communication capabilities (*e.g.*, portable telecommunication device, wireless communication device, mobile phone, smartphone, cell phone, computing device, camera, tablet computer, laptop computer, convertibles, personal digital assistants (PDAs), smartwatches, intelligent glasses, and so forth). While in this publication, an example mobile device is described as a smartphone; other types of mobile devices can also support the methods described in this publication.

A smartphone may unexpectedly experience an interruption of power and cease charging for several reasons, for example, the displacement of a charging cable from a wall socket or a power outage resulting from a natural disaster (*e.g.,* earthquake, tornado, tropical storm, hurricane). Such an interruption of power may result in a user, for example, after waking from sleep, realizing that their smartphone did not recharge overnight and that as a result of activity on

the smartphone (*e.g.*, notifications received, background refreshes), the battery life of the smartphone is now low. In a worst-case scenario, the user may discover that the battery of the smartphone is fully discharged. In a situation where a power outage results from a natural disaster, maximization of the battery life of the user's smartphone may be crucial for the safety of the user (*e.g.*, so the user can contact authorities and/or family members).

In contrast, consider the disclosed methods, where the smartphone utilizes data from one or more sensors to determine that an unexpected charging interruption has occurred and, in response, the smartphone automatically enters an energy-saving mode. This is but one example of how the described methods may be used to maximize the battery life of a smartphone that experiences an unexpected charging interruption. Other examples and implementations are described throughout this document.

In aspects, the smartphone includes a processor, at least one sensor (*e.g.*, accelerometer, gyroscope, motion sensor, a radar sensor, power sensor), and an input/output device (*e.g.*, a display, a speaker, a haptic mechanism (a vibration mechanism)). One or more of the sensors may generate motion data. Motion data may include device movement (*e.g.*, smartphone was picked up, smartphone was set down, common movements associated with a user plugging and/or unplugging a charge cable) or movement of the surroundings (*e.g.*, objects adjacent to the device moved).

The smartphone also includes a computer-readable medium (CRM). The CRM may include any suitable memory or storage device (*e.g.*, random-access memory (RAM), static RAM (SRAM), dynamic RAM (DRAM), non-volatile RAM (NVRAM), read-only memory (ROM), flash memory). A power manager application (PMA) is implemented on the CRM. The smartphone performs operations under the direction of the PMA to automatically enable an energy-

saving mode in the event of an unexpected interruption to charging so that the battery life of the smartphone can be extended.

The smartphone also includes a power management module for monitoring and managing the charging of the battery or within a charger circuit. In aspects, the power management module may be implemented in the CRM. In aspects, the power quality data is a signal received from the charger. The power management module is configured to monitor the charging status of the battery (*e.g.*, charging, not charging) and to monitor power quality data (*e.g.*, current, voltage).

The operations performed under the direction of the PMA may include monitoring for the interruption of the charging cycle and determining that an unexpected charging cycle interruption has occurred. The PMA may also request an automatic enabling of energy-saving mode. In aspects, the power quality data can be reviewed by the PMA to determine the presence of power metrics indicative of an unexpected interruption of charging, for example, a power outage.

In aspects, the PMA analyzes motion data to determine the presence of motion that occurred contemporaneously with the interruption in the charging cycle. An expected interruption in the charging cycle may be associated with certain movements of the smartphone (*e.g.*, detected by a gyroscope, detected by an accelerometer) and/or of the objects surrounding the smartphone (*e.g.*, detected by a radar sensor). A user typically picks up or moves a smartphone in the process of unplugging it. This motion data is captured by motion sensors, for instance, a gyroscope and/or an accelerometer. A user may also walk toward the smartphone or move their hand toward the smartphone in the process of unplugging it. This motion data is captured by a radar sensor. Data that indicates common motion indicative of a user intentionally interrupting the charging cycle is normal motion data.

The motion data may indicate that the user was unaware of a charging interruption, for example, motion data indicative of a cable falling out of a powered wall socket, or any other sudden unexpected interruptions. Typically, an unexpected interruption is not coupled with motion from the smartphone or its surroundings. In aspects, the PMA receives power quality data and motion data to determine if a sudden interruption in charging was expected.

Responsive to determining that charging was interrupted unexpectedly, the smartphone enables an energy-saving mode to extend the battery life of the smartphone. For example, the PMA can direct the processor and/or an operating system implemented on the CRM to enter the energy-saving mode. In aspects, upon entering the energy-saving mode, the PMA can trigger a notification to be provided on an input/output device. For example, the PMA can trigger a notification to be displayed on the display of the smartphone.

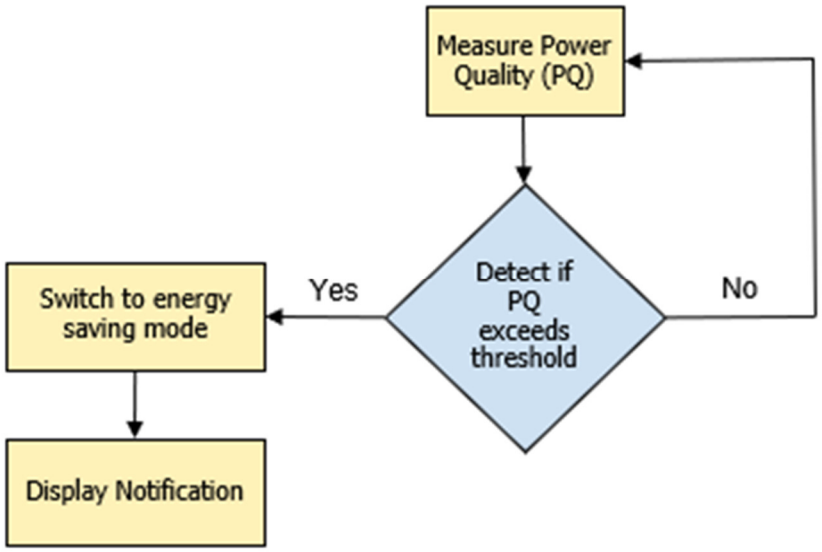

Figure 1

As illustrated in Figure 1, the power management module measures power quality (PQ) and generates power quality data (*e.g.*, current, voltage). The PMA receives the power quality data from the power management module and analyzes the power quality data to detect

abnormalities in power quality based on a predetermined threshold. If power quality exceeds that threshold, the PMA may determine that the loss of power was unexpected. To make this determination, motion data is analyzed for abnormal sensor data corresponding to an interruption in the charging cycle. The PMA may then enable energy-saving mode and display a notification to the user indicating the same.

As a result of enabling energy-saving mode, notifications from a text message, email, or various other notifications may be delayed or not displayed at all. The energy-saving mode feature described in this publication, then, could be an opt-in feature for the user. It may also be a feature that is only enabled if the Do Not Disturb feature on the smartphone is also in use. Do Not Disturb is a feature that silences some or all notifications. When a smartphone has Do Not Disturb enabled and is plugged in, the user will not receive notifications regardless, so there is no longer a risk in missing anything if an energy-saving mode is enabled.

In a first example use, a user plugs their smartphone into a powered charging cable and places their smartphone down on their nightstand. After charging for a few minutes, the user's dog trips on the charging cable, resulting in the charging cable unplugging from the power supply. As a result, the charging cycle of the smartphone is interrupted. The user is unaware of this power interruption and does not plug the charging cable back into the power supply. Responsive to the interruption of the charging cycle, the smartphone determines if the interruption of the charging cycle was expected by analyzing motion data (*e.g.*, from a gyroscope, from an accelerometer) to determine if one or more patterns in the motion data indicate that the user intentionally interrupted the charging cycle. The motion data may indicate motion associated with a charging cable being unintentionally unplugged (*e.g.*, due to a charging cable being tripped over). Upon determining that the interruption of the charging cycle was unexpected, the smartphone enters an energy-saving

mode and displays a notification on the display screen of the smartphone indicating to the user that the energy-saving mode was entered. Through such an action, the smartphone maximizes battery life in case power is not restored. In aspects, upon a restoration of the supply of power to the smartphone (*e.g.*, the user plugs the charging cable back into the power supply), the energy-saving mode could be automatically disabled.

In a second example use, a user plugs their smartphone into a powered charging cable and places their smartphone down on their nightstand. After the user falls asleep, but before the smartphone has completed its charging cycle, a thunderstorm causes a power surge at the power station that supplies the user's home. The power surge results in a complete power outage, interrupting the charging cycle of the smartphone. Responsive to the interruption of the charging cycle, the smartphone determines that the interruption of the charging cycle was caused by a power surge by analyzing power quality data. After determining that the interruption in charging was unexpected, through abnormal sensor data, the smartphone can automatically enable energy-saving mode. The smartphone may also display a notification for the user explaining that energy-saving mode was enabled. By enabling energy-saving mode, the smartphone maximizes battery life in case power is not restored. This would allow the user to make phone calls, send texts, or anything that the situation required. In aspects, upon restoration of the supply of power to the smartphone (*e.g.,* the power station resuming operation), the energy-saving mode could be automatically disabled.

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