

METHOD AND APPARATUS FOR REDUCING POWER CONSUMPTION IN A MOBILE ELECTRONIC DEVICE

5 [0001] The present application claims priority to U.S. Non-Provisional Application No. 14/329,663,
filed July 11, 2014, titled "Method and Apparatus for Reducing Power Consumption in a Mobile
Electronic Device," and to U.S. Patent Application Serial Number 14/243,673, entitled "METHOD
AND APPARATUS FOR REDUCING POWER CONSUMPTION IN A MOBILE ELECTRONIC
10 DEVICE," filed on April 2, 2014, and to U.S. Patent Application Serial Number 14/137,490,
entitled "METHOD AND APPARATUS FOR REDUCING POWER CONSUMPTION IN A
MOBILE ELECTRONIC DEVICE," filed on December 20, 2013, all of which applications are
hereby incorporated herein by reference.

TECHNICAL FIELD

15 [0002] This invention generally relates to mobile electronic devices, and more specifically to a
method and apparatus of reducing power consumption in a mobile electronic device.

BACKGROUND

20 [0003] Current mobile electronic devices such as smartphones and tablet computers on the market
suffer from significantly decreased battery life in comparison with previous generations of
smartphones and feature phones due to enriched communication capabilities as well as more
complex applications provided by such devices. While modern phones offer a richer and more
pleasing experience to end users with the variety of data driven features, the customer's ability to
utilize a very basic calling functionality has been dramatically reduced due to the shortened battery
25 life between charging cycles. This leads to numerous situations where users can no longer place
basic voice calls when the battery reaches a near-depletion level.

[0004] In order to extend battery life, users may manually turn off functions to save power. For
example, users may turn off Bluetooth, Wi-Fi, and vibrate and keytones etc. Users may also lower
the screen brightness, set a shorter screen timeout, etc.

communicate over one or more communication buses or signal lines. The mobile electronic device 100 can be, for example, a handheld computer, a tablet computer, a mobile phone, a media player or a personal digital assistant (PDA). The various components shown in FIG. 2 may be implemented in hardware or a combination of hardware and software, including one or more signal processing and/or application specific integrated circuits.

[0016] The memory 130 may include high speed random access memory and may also include non-volatile memory, such as one or more magnetic disk storage devices, flash memory devices, or other non-volatile solid state memory devices. Access to the memory 130 by other components of the device 100, such as the CPU 101, the GPU 103, and the peripherals interface 107, may be controlled by the memory controller 105.

[0017] In other embodiments of the present invention, the memory 130 may include storage remotely located from the mobile electronic device 100, for instance network attached storage accessed via the RF circuitry 170 or external port 180 and a communications network (not shown) such as the Internet, intranet(s), Local Area Networks (LANs), ~~Wide~~ Wireless Local Area Networks (WLANs), Storage Area Networks (SANs) and the like, or any suitable combination thereof.

[0018] Referring back to Fig. 2, the peripherals interface 107 couples the input and output peripherals of the device 100 to the CPU 101, the GPU 103 and the memory 130. The CPU 101 runs various software programs and/or sets of instructions stored in the memory 130 to perform various functions for the device 100 and to process data. The GPU 103 handles graphic processing functions for the screen 111. In some embodiments, the graphic processing functions are handled by the CPU 101, so the GPU 103 may be replaced.

[0019] The external port 180 is adapted for coupling to other devices either directly or remotely over a network. For example, the external port 180 could comprise a Universal Serial Bus (USB), FireWire, memory slot for receiving an external storage medium, etc.

[0020] RF (radio frequency) circuitry 170 receives and sends RF signals, also called electromagnetic signals. RF circuitry 170 converts electrical signals to/from electromagnetic signals and communicates with communications networks and other communications devices via the electromagnetic signals. RF circuitry 170 may include well-known circuitry for performing these functions, including but not limited to an antenna system, an RF transceiver, one or more amplifiers, a tuner, one or more oscillators, a digital signal processor, a CODEC chipset, a subscriber identity module (SIM) card, memory, and so forth. RF circuitry 170 may communicate with networks, such as the Internet, an intranet and/or a wireless network, such as a cellular telephone network, a wireless local area network (WLAN) and/or a metropolitan area network (MAN), and other devices by

the activating module 132 terminates the currently running first launcher 134, and proceeds to step 306.

[0038] In step 306, activate the second launcher 135 using the activating module 132.

[0039] In step 304, activate the function limiting module 136. The activating module 132 may activate the function limiting module 136 to start degrading or disabling functions of the device 100. It should be noted that the threshold for starting the second launcher 135 and the threshold for starting the function limiting module 136 may or may not be the same threshold.

[0040] In step 307, disable or degrade functions. Once the second launcher 135 is activated, the second launcher 135 as defined above may disable or degrade the GPU, eliminate graphical effects, degrade display resolution, scale down CPU frequency and/or perform other functions described above.

[0041] More specifically, referring to FIG. 4B, step 307 may further include one or more of steps 307A-307E.

[0042] In step 307A, disable or minimize GPU support. The second launcher 135 has disabled or minimized GPU support. The second launcher 135 instructs the lower level software, such as operating system (OS) kernel, via system calls to either drive and fix the frequency of the GPU 103 at the minimum allowed level or power the GPU 103 down through the available GPU hardware interfaces. Instead, the second launcher 135 may be designed to render the graphics using the CPU 101.

[0043] In step 307B, disable scrolling, rotation, or animation. The second launcher 135 disables support for one or more graphical effects include scrolling, rotation, and animation.

[0044] In step 307C, scale down CPU frequency. The second launcher 135 may include code for scaling down CPU frequency to the minimum operational level. If the CPU has multiple cores, the CPU may be set to the single core mode. The launcher will do this via system calls instructing lower level software components, such as the OS kernel to scale down the CPU frequency and disable additional cores through the CPU governor and CPU hot-plug interfaces.

[0045] In step 307D, disable graphical or text notifications other than battery level and Received Signal Strength Indicator (RSSI). The second launcher 135 will support status information to the battery level, the RSSI and the clock. No other graphical or text notifications will be supported.

[0046] In step 307E, degrade brightness of the display, and degrade display resolution. The second launcher 135 may further includes code for utilizing system calls instructing the lower level SW components, such as the OS kernel, to degrade the display resolution, refresh rate, or brightness through the respective device drivers.

WHAT IS CLAIMED IS:

1. A method of operating a mobile electronic device, the method comprising:
 - monitoring, by the mobile electronic device, a power level of a battery powering the mobile electronic device;
 - determining, by the mobile electronic device, that the power level of the battery has reached a battery power level threshold; and
 - upon the determining:
 - disabling, by the mobile electronic device, one or more first applications on the mobile electronic device, wherein one or more second applications remains enabled; and
 - disabling, by the mobile electronic device, display of respective icons for the disabled one or more first applications on a screen of the mobile electronic device when the screen is on.
2. The method of claim 1, further comprising, upon the determining, disabling one or more hardware functions in the mobile electronic device, wherein each of the one or more first applications utilize at least one of the one or more hardware functions.
3. The method of claim 2, wherein the hardware functions include Bluetooth and Wi-Fi.
4. The method of claim 1, wherein the one or more second applications comprise a voice communication function and a text messaging function.
5. The method of claim 4, further comprising, upon the determining, displaying on the screen a voice communication icon and a text messaging icon corresponding to the voice communication function and the text messaging function, respectively.
6. The method of claim 1, wherein disabling the one or more first applications comprises disabling two or more of a music player application, a video player application, a camera application, and a photo gallery application.
7. The method of claim 1, wherein disabling the one or more first applications comprises disabling a music player application, a video player application, a camera application, and a photo gallery application.

8. The method of claim 7, wherein disabling display of the respective icons comprises not displaying a music player application icon, a video player application icon, a camera application icon, and a photo gallery application icon.
9. The method of claim 7, wherein disabling the one or more first applications comprises disabling social networking applications.
10. The method of claim 7, wherein disabling the one or more first applications comprises disabling an Internet browser application.
11. The method of claim 1, further comprising, upon the determining, degrading one or more display characteristics of the screen.
12. The method of claim 11, wherein degrading the one or more display characteristics comprises lowering one or more of screen brightness, screen timeout, refresh rate, and screen resolution.
13. The method of claim 11, wherein degrading the one or more display characteristics comprises degrading graphics effects on the screen of the mobile electronic device.
14. The method of claim 13, wherein degrading the graphics effects comprises disabling one or more of scrolling, rotation, and animation.
15. The method of claim 1, further comprising, upon the determining, degrading performance of a central processor unit (CPU) in the mobile electronic device.
16. The method of claim 15, wherein degrading performance of the CPU comprises scaling down a CPU frequency of the CPU.
17. The method of claim 15, wherein degrading performance of the CPU comprises disabling a core of the CPU.
18. The method of claim 1, further comprising, upon the determining, degrading performance of a graphics processing unit (GPU) in the mobile electronic device.

19. The method of claim 18, wherein degrading performance of the GPU comprises powering down the GPU.
20. The method of claim 18, wherein degrading performance of the GPU comprises lowering a GPU frequency of the GPU.
21. The method of claim 1, further comprising, upon the determining, lowering a radio mode of a radio modem in the mobile electronic device.
22. The method of claim 1, further comprising, upon the determining, disabling notifications on the screen, wherein battery level, received signal strength indicator and clock notifications remain enabled on the screen.
23. The method of claim 1, further comprising, upon the determining, disabling one or more of external storage, additional speakers, and external light emitting diodes (LEDs).
24. The method of claim 1, wherein the battery power level threshold is set by a user of the mobile electronic device.
25. The method of claim 1, wherein the battery power level threshold is configured by a manufacturer the mobile electronic device.
26. The method of claim 1, wherein the battery power level threshold is set at 20% of a full power level of the battery.
27. The method of claim 1, further comprising, after the determining:
detecting a second power level of the battery is above the battery power level threshold; and
enabling a normal operating mode of the mobile electronic device, thereby providing a full user experience.
28. The method of claim 1, further comprising, upon the determining:
terminating a first launcher running on the mobile electronic device, wherein the first launcher presents full user experience icons on the screen for starting respective full user experience applications; and

activating a second launcher on the mobile electronic device, wherein the second launcher presents reduced user experience icons on the screen for starting respective reduced user experience applications.

29. The method of claim 1, wherein the mobile electronic device is a smartphone or a tablet device.

30. A method of operating a mobile electronic device, the method comprising:

monitoring, by the mobile electronic device, a power level of a battery powering the mobile electronic device;

determining, by the mobile electronic device, that the power level of the battery has reached a battery power level threshold; and

entering, by the mobile electronic device, a power save mode in accordance with the determining, wherein entering the power save mode comprises:

disabling, by the mobile electronic device, one or more applications on the mobile electronic device, wherein a voice communication function and a text messaging function remain enabled;

displaying, by the mobile electronic device, a voice communication icon corresponding to the voice communication function, and a text messaging icon corresponding to the text messaging function, without displaying respective application icons for the disabled one or more applications, on a screen of the mobile electronic device; and

degrading, by the mobile electronic device, one or more display characteristics of the screen.

31. The method of claim 30, wherein entering the power save mode further comprises disabling one or more hardware functions in the mobile electronic device, wherein each of the one or more applications utilize at least one of the one or more hardware functions.

32. The method of claim 31, wherein the hardware functions include Bluetooth and Wi-Fi.

33. The method of claim 30,

wherein disabling the one or more applications comprises disabling a music player application, a video player application, a camera application, and a photo gallery application; and

wherein the without displaying the respective application icons for the disabled one or more applications comprises not displaying a music player application icon, a video player application icon, a camera application icon, and a photo gallery application icon on the screen.

34. The method of claim 30, wherein degrading the one or more display characteristics comprises:
degrading graphics effects on the screen of the mobile electronic device; and
lowering a screen timeout.
35. The method of claim 34, wherein degrading the one or more display characteristics comprises
lowering a brightness of the screen.
36. The method of claim 30, wherein entering the power save mode further comprises:
disabling Bluetooth and Wi-Fi; and
disabling a plurality of notifications on the screen, wherein battery level, received signal
strength indicator and clock notifications remain enabled on the screen.
37. The method of claim 30, wherein entering the power save mode further comprises:
disabling a core of a central processing unit (CPU); and
scaling down a CPU frequency of the CPU.
38. The method of claim 30, wherein entering the power save mode further comprises degrading
performance of a graphics processing unit (GPU) in the mobile electronic device.
39. The method of claim 38, wherein degrading performance of the GPU comprises powering down
the GPU.
40. The method of claim 38, wherein degrading performance of the GPU comprises lowering a GPU
frequency of the GPU.
41. The method of claim 30, wherein entering the power save mode further comprises lowering a
radio mode of a radio modem in the mobile electronic device.
42. The method of claim 30, wherein the battery power level threshold is set by a user of the mobile
electronic device.
43. The method of claim 30, wherein the battery power level threshold is configured by a
manufacturer the mobile electronic device.

44. The method of claim 30, wherein the battery power level threshold is set at 20% of a full power level of the battery.

45. A mobile electronic device comprising:

a screen;

a processor; and

a non-transitory computer-readable storage medium storing programming for execution by the processor, the programming including instructions to:

monitor a power level of a battery powering the mobile electronic device;

determine that the power level of the battery has reached a battery power level threshold;

and

enter a power save mode in accordance with determining that the power level of the battery has reached a battery power level threshold, wherein the instructions to enter the power save mode comprise instructions to:

disable one or more applications on the mobile electronic device, wherein a voice communication function and a text messaging function remain enabled;

display a voice communication icon corresponding to the voice communication function, and a text messaging icon corresponding to the text messaging function, without displaying respective application icons for the disabled one or more applications, on the screen of the mobile electronic device; and

degrade one or more display characteristics of the screen.

46. A mobile electronic device comprising:

a screen;

a non-transitory computer-readable memory;

a processor coupled to the memory and configured to:

monitor a power level of a battery powering the mobile electronic device;

determine that the power level of the battery has reached a battery power level threshold;

and

enter a power save mode in accordance with determining that the power level of the battery has reached the battery power level threshold, wherein the processor configured to enter the power

save mode comprises the processor configured to:

disable one or more applications on the mobile electronic device, wherein a voice communication function and a text messaging function remain enabled;

display a voice communication icon corresponding to the voice communication function, and a text messaging icon corresponding to the text messaging function, without displaying respective application icons for the disabled one or more applications, on the screen of the mobile electronic device; and

degrade one or more display characteristics of the screen.

47. A method of operating a mobile electronic device, the method comprising:

receiving, by the mobile electronic device, an indication to enter a power save mode; and

entering, by the mobile electronic device, the power save mode in accordance with the receiving, wherein entering the power save mode comprises:

disabling, by the mobile electronic device, one or more applications on the mobile electronic device, wherein a voice communication function and a text messaging function remain enabled;

displaying, by the mobile electronic device, a voice communication icon corresponding to the voice communication function, and a text messaging icon corresponding to the text messaging function, without displaying respective application icons for the disabled one or more applications, on a screen of the mobile electronic device; and

degrading, by the mobile electronic device, one or more display characteristics of the screen.

48. The method of claim 47,

wherein degrading the one or more display characteristics comprises:

lowering screen brightness;

lowering screen refresh rate; and

degrading animation, scrolling and rotation effects; and

wherein entering power save mode further comprises:

disabling a core of a central processing unit (CPU) in the mobile electronic device;

scaling down a CPU frequency of the CPU; and
disabling one or more hardware functions in the mobile electronic device, wherein each of the one or more applications utilize at least one of the one or more hardware functions.

49. The method of claim 48, wherein the hardware functions include Bluetooth and Wi-Fi.

Claims:

1. A mobile electronic device, comprising:
 - a processor;
 - a memory coupled to the processor and storing programming for execution by the processor; and
 - a screen for displaying graphic information;
 - the processor being configured to execute the programming to perform operations of:
 - receiving an indication to enter a power saving mode;
 - in response to receiving the indication to enter the power saving mode:
 - switching from a first launcher running on the mobile electronic device to a second launcher different from the first launcher, wherein the first launcher and the second launcher are software programs that present links on a screen of the mobile electronic device for starting other software programs installed in the mobile electronic device, wherein the first launcher presents a first set of application icons, the second launcher presents a second set of application icons, and the application icons are for activating corresponding applications, wherein the second set contains fewer application icons as compared to the first set, and the second set includes a voice communication icon corresponding to a voice communication function and a text messaging icon corresponding to a text messaging function;
 - degrading one or more display characteristics on the screen of the mobile electronic device; and
 - disabling a plurality of notifications on the screen, wherein battery level status information, signal strength status information and clock status information remain on the screen.
2. The mobile electronic device of claim 1, wherein the processor is further configured to execute the programming to perform an operation of:
 - disabling a Bluetooth function or a Wi-Fi function in the mobile electronic device.
3. The mobile electronic device of claim 1, wherein the processor is further configured to execute the programming to perform an operation of:
 - reducing a central processing unit (CPU) frequency and disabling at least one core of a CPU in the mobile electronic device.

4. The mobile electronic device of claim 1, wherein the processor is further configured to execute the programming to perform an operation of:

reducing a graphics processing unit (GPU) frequency of a GPU in the mobile electronic device.

5. The mobile electronic device of claim 1, wherein the processor is further configured to execute the programming to perform an operation of:

lowering a radio mode of a radio modem in the mobile electronic device.

6. The mobile electronic device of claim 1, wherein degrading the one or more display characteristics comprises:

lowering screen brightness; or

lowering screen refresh rate.

7. The mobile electronic device of claim 1, wherein degrading the one or more display characteristics comprises:

displaying only black-and-white images on the screen of the mobile electronic device;

or

lowering a screen timeout.

8. The mobile electronic device of claim 1, wherein the plurality of application icons include a data service application icon, a music player application icon, a video player application icon, a camera application icon, and a photo gallery application icon.

9. The mobile electronic device of claim 1, wherein receiving the indication to enter the power saving mode comprises:

monitoring a power level of a battery powering the mobile electronic device; and

determining that the power level of the battery has reached a battery power level threshold.

10. The mobile electronic device of claim 1, wherein the switching from the first launcher to the second launcher comprises:

terminating the first launcher running on the mobile electronic device.

11. The mobile electronic device of claim 1, wherein the mobile electronic device is a smartphone or a tablet device.

12. The mobile electronic device of claim 1, wherein before switching, the first launcher is running on an operating system of the mobile electronic device, and after switching, the second launcher is running on the operating system of the mobile electronic device.

13. The mobile electronic device of claim 12, wherein the operating system includes an Android system.

14. A mobile electronic device, comprising:

a processor;

a memory coupled to the processor and storing programming for execution by the processor; and

a screen for displaying graphic information;

the processor being configured to execute the programming to perform operations of:

receiving an indication to enter a power saving mode;

in response to receiving the indication to enter the power saving mode:

switching from a first launcher running on the mobile electronic device to a second launcher different from the first launcher, wherein the first launcher and the second launcher are software programs that present links on a screen of the mobile electronic device for starting other software programs installed in the mobile electronic device, wherein the first launcher presents a first set of application icons, the second launcher presents a second set of application icons, and the application icons are for activating corresponding applications, wherein the second set contains fewer application icons as compared to the first set, the second set includes a voice communication icon corresponding to a voice communication function and a text messaging icon corresponding to a text messaging function, wherein the second launcher has degraded display characteristics on the screen of the mobile electronic device as compared to the first launcher, and a battery level status indicator, a signal strength status indicator, and a current time indicator remain on the screen after switching from the first launcher to the second launcher.

15. The mobile electronic device of claim 14, wherein the processor is further configured to execute the programming to perform an operation of:

disabling a Bluetooth function or Wi-Fi function in the mobile electronic device.

16. The mobile electronic device of claim 14, wherein the processor is further configured to execute the programming to perform an operation of:

reducing a central processing unit (CPU) frequency and disabling at least one core of a CPU in the mobile electronic device.

17. The mobile electronic device of claim 14, wherein the processor is further configured to execute the programming to perform an operation of:

reducing a graphics processing unit (GPU) frequency of a GPU in the mobile electronic device.

18. The mobile electronic device of claim 14, wherein the degraded display characteristics comprise:

lower screen brightness, a lower screen refresh rate, only black-and-white images on the screen of the mobile electronic device, or a lower screen timeout.

19. The mobile electronic device of claim 14, wherein the plurality of application icons include a data service application icon, a music player application icon, a video player application icon, a camera application icon, and a photo gallery application icon.

20. The mobile electronic device of claim 14, wherein receiving the indication to enter the power saving mode comprises:

monitoring a power level of a battery powering the mobile electronic device; and
determining that the power level of the battery has reached a battery power level threshold.

21. The mobile electronic device of claim 14, wherein the switching from the first launcher to the second launcher comprising:

terminating the first launcher running on the mobile electronic device.

22. A method performed by a mobile electronic device for power saving, the method comprising:

receiving, by the mobile electronic device, an indication to enter a power saving mode;

in response to receiving the indication to enter the power saving mode:

switching, by the mobile electronic device, from a first launcher running on the mobile electronic device to a second launcher different from the first launcher, wherein the first launcher and the second launcher are software programs that present links on a screen of the mobile electronic device for starting other software programs installed in the mobile electronic device, wherein the first launcher presents a first set of application icons, the second launcher presents a second set of application icons, and the application icons are for activating corresponding applications, wherein the second set contains fewer application icons as compared to the first set, the second set includes a voice communication icon corresponding to a voice communication function and a text messaging icon corresponding to a text messaging function, and the second launcher has degraded display characteristics on a screen of the mobile electronic device as compared to the first launcher; and

disabling, by the mobile electronic device, a plurality of notifications on the screen, wherein battery level status information, signal strength status information and clock status information remain on the screen.

23. The method of claim 22, wherein the method further comprises:

disabling, by the mobile electronic device, a Bluetooth function or a Wi-Fi function in the mobile electronic device.

24. The method of claim 22, wherein the method further comprises:

reducing a central processing unit (CPU) frequency and disabling at least one core of a CPU in the mobile electronic device.

25. The method of claim 22, wherein the method further comprises:

reducing a graphics processing unit (GPU) frequency of a GPU in the mobile electronic device.

26. The method of claim 22, wherein the method further comprises:

lowering, by the mobile electronic device, a radio mode of a radio modem in the mobile electronic device.

27. The method of claim 22, wherein degrading the one or more display characteristics comprises:

lowering screen brightness; or
lowering screen refresh rate.

28. The method of claim 22, wherein degrading the one or more display characteristics comprises:

displaying only black-and-white images on the screen of the mobile electronic device;
or
lowering a screen timeout.

29. The method of claim 22, wherein the plurality of application icons include a data service application icon, a music player application icon, a video player application icon, a camera application icon, and a photo gallery application icon.

30. The method of claim 22, wherein receiving the indication to enter the power saving mode comprises:

monitoring a power level of a battery powering the mobile electronic device; and
determining that the power level of the battery has reached a battery power level threshold.

31. The method of claim 22, wherein the switching from the first launcher to the second launcher comprising:

terminating the first launcher running on the mobile electronic device.