November 2020

Aggressive Smartphone Thermal Mitigation at High Temperatures

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AGGRESSIVE SMARTPHONE THERMAL MITIGATION AT HIGH TEMPERATURES

Abstract

Thermal mitigation at a smartphone is improved by employing an emergency disconnect mode that is entered in response to heat at the smartphone exceeding a specified threshold. In the emergency disconnect mode, the smartphone is disconnected from a cellular network. This allows the components of a radio front-end of the smartphone to be turned off or placed in a low power mode while the smartphone is in the emergency disconnect mode, thereby rapidly decreasing the amount of heat generated at the device and allowing the smartphone to return to a normal mode of operation more quickly.

Background

While in operation, the electronic components of a smartphone generate heat that can, at excessive levels, damage the electronic components. Accordingly, to protect the electronic components, the smartphone can employ one or more approaches to heat mitigation, such as shutting down the smartphone when the heat exceeds a specified shutdown threshold. Another approach to heat mitigation is to disable data access at the smartphone when the heat exceeds an intermediate threshold (lower than the shutdown threshold). If the device heat continues to increase, the smartphone enters an emergency access mode, wherein the smartphone permits only emergency calls to be made from the device, and disables execution of applications and other device operations, thereby reducing overall activity at the smartphone, and thus reducing the amount of heat generated by the device. However, in the typical emergency access mode, the radio front-end of the smartphone that connects the smartphone to a cellular network is maintained in an active mode. Further, in the emergency access mode, the smartphone periodically performs operations to maintain connection to the cellular network, such as paging

and cell selection. These activities consume power and limit the effectiveness of the thermal mitigation.

Description

As described in more detail below, thermal mitigation at a smartphone can be implemented by employing an emergency disconnect mode in response to heat at the smartphone exceeding a specified intermediate threshold. The emergency disconnect mode is similar to a device airplane mode, wherein the smartphone is disconnected from the cellular network. This allows the components of the radio front-end of the smartphone to be turned off or placed in a low power mode while the smartphone is in the emergency disconnect mode, thereby rapidly decreasing the amount of heat generated at the device and allowing the smartphone to return to a normal mode of operation more quickly.

To further illustrate, a flow diagram depicting a process for entry into the different thermal modes is shown at Figure 1, below:

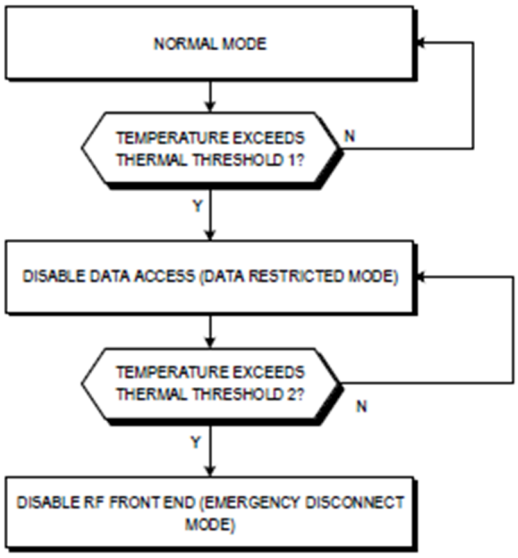

FIG. 1

As illustrated, a smartphone is initially in a normal mode, wherein the smartphone can conduct all normal operations, including maintaining a connection to a cellular network, sending and receiving data via the cellular network, and executing applications at an application processor of the smartphone. As long as a detected temperature at the smartphone stays below a specified thermal threshold (designated Thermal Threshold 1), the smartphone maintains itself in the normal mode.

In response to the detected temperature exceeding Thermal Threshold 1, a controller or processor of the smartphone attempts to mitigate heat at the device by entering a data restricted mode and disabling data access to the cellular network. In the data restricted mode, voice access is maintained, and other operations at the device may be allowed, such as execution of at least a subset of applications. If the temperature at the smartphone continues to increase and exceeds a second thermal threshold (designated Thermal Threshold 2), the controller or processor places the smartphone in the emergency disconnect mode by placing a radio-frequency (RF) front-end of the device in a shutdown state, placing any software executing at a radio or modem of the device in a suspended mode, and forcing any modem processor (e.g., a separate digital signal processor (DSP)) in a power save mode. By deactivating these components, the smartphone achieves additional thermal savings and can return to the normal mode more quickly.

Deactivating the RF front-end prevents the smartphone from connecting to the cellular network. Accordingly, as noted above, the emergency disconnect mode functions as a "pseudo-airplane" mode, in that the smartphone is generally prevented from connecting to the cellular network for data communication and for non-emergency voice calls. However, the emergency disconnect mode is not indicated as an airplane mode to the user.

Emergency voice calls are permitted in the emergency disconnect mode. Figure 2, depicted below, illustrates a process for establishing an emergency voice call in the emergency disconnect mode.

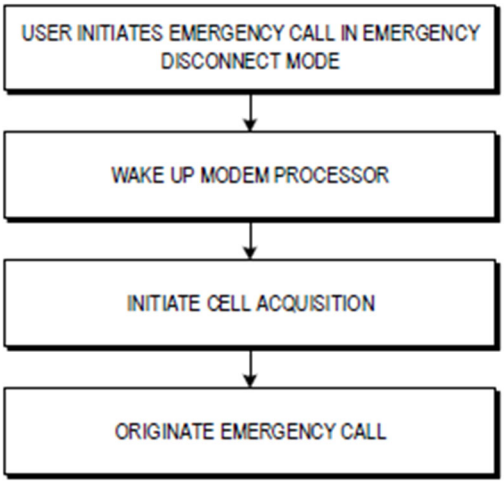

FIG. 2

As illustrated, the user initiates an emergency call while the smartphone is in the emergency disconnect mode, such as by inputting a specified emergency number (e.g., 911). In response, a controller or processor of the smartphone wakes up the smartphone's modem processor. The modem processor initiates cell acquisition at the cellular network and, upon acquiring the cell, originates the emergency call at the cellular network. The process takes a relatively short amount of time (e.g., a few seconds), allowing the user to make emergency calls while also supporting more aggressive heat mitigation.

References

1. U.S. Patent Application Serial No. 20140200685, entitled "Thermal Mitigation in Dual SIM Dual Active Devices," and filed on July 17, 2014, the entirety of which is incorporated by reference.

2. U.S. Patent Application Serial No. 20110230163, entitled “Methods and Apparatus for Limiting Communication Capabilities in Mobile Communication Devices,” and filed on September 22, 2011, the entirety of which is incorporated by reference.

3. U.S. Patent Application Serial No. 20100330950, entitled “Device and Method for Temperature Monitoring and Warning,” and filed on December 30, 2010, the entirety of which is incorporated by reference.