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Time Deadline For Modem Mitigation Actions In Regards To Thermal Mitigation

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Time Deadline For Modem Mitigation Actions In Regards To Thermal Mitigation

Abstract:

This publication describes techniques for dynamic mitigation actions performed by a modem in response to a thermal situation. Dynamic mitigation actions can be completed by a modem after it receives a deadline time calculated by a caller (*e.g.*, Application Programming Interface (API)) of the modem based on the thermal situation. The deadline time will represent how long the modem has to fully complete one or more mitigation action(s). The modem can decide the mitigation action timeline based off of the deadline time to allow for a better user experience. For example, if it is determined that the thermal situation is less critical (*e.g.*, the temperature is increasing very slowly), a longer deadline time can be communicated from the API to allow the modem to slowly mitigate processes executing on the device. If it is determined that the thermal situation is more critical, the mitigation can be more aggressive with a shorter deadline time.

Keywords:

modem, cellular, 4G LTE, 5G NR, multiple carriers, multiple channels, multiple antennas, high-speed uploading, high-speed downloading, temperature, thermal, mitigation, modem mitigation, thermal mitigation, deadline time, carrier aggregation

Background:

An electronic device, such as a smartphone, uses a modem to communicate with a base station (*e.g.*, cellular tower) to provide voice and data capabilities. The electronic device can communicate with the base station using multiple carrier technologies (*e.g.*, 4G Long-Term

Evolution (LTE), 5G new radio (NR)) to improve throughput. The electronic device can also utilize multiple antennas, high-speed uploading, and high-speed downloading by the modem. These technologies are resource-intensive and can increase the temperature of the electronic device to temperatures that can shutdown the electronic device. The electronic device has mitigation actions in place to avoid thermal shutdown due to overheating. Currently, for example, mitigation actions performed by a modem in response to a thermal situation are statically defined. At boot up, a modem reads in configuration files to set timers for how fast the modem completes actions. A disadvantage to this static process is that there is no ability to dynamically change how fast mitigation actions performed by a modem execute.

For example, 4G LTE technology allows an electronic device to transmit to a base station with multiple channels or carriers. The base station can communicate more quickly with the electronic device with multiple carriers, but the utilization of multiple carriers can cause the temperature of the electronic device to increase. Currently, if the temperature of the electronic device reaches a threshold, the algorithms in the configuration files read by the modem use a fixed timer to remove carriers to decrease heat. When a fixed time period expires, the modem removes a carrier. The fixed timer is then restarted, and the modem continues this process until it is in its lowest state with one carrier to receive/transmit data on. The fewer the number of carriers, the slower the throughput. Therefore, it is desirable to have greater flexibility with mitigation actions performed by a modem in response to a thermal situation.

Description:

This publication describes techniques for dynamic mitigation actions performed by a modem in response to a thermal situation detected by an electronic device. Dynamic mitigation

actions can be completed by a modem after it receives a deadline time based on the thermal situation detected by the electronic device. The deadline time will represent how long the modem has in order to fully complete a mitigation action. The modem can determine the mitigation action timeline to be completed within the deadline time period. The deadline time will be calculated by a high level operating system (*e.g.*, Android) on the device and be communicated to the modem through an Application Programming Interface (API). If it is determined that the thermal mitigation required is less critical (*e.g.*, the temperature is increasing very slowly), a longer deadline time can be supplied to allow the modem to slowly mitigate the device. If it is determined that the thermal mitigation required is more critical, the modem mitigation can be more aggressive with a shorter deadline time.

An electronic device, such as a smartphone, includes a dynamic modem mitigation application that can call the modem. The electronic device performs operations under the direction of the dynamic modem mitigation application to communicate a deadline time for a modem mitigation action to a modem on the electronic device. The operations include receiving temperature information from one or more sensors, assigning a priority to the thermal situation, calculating a deadline time, and communicating the deadline time to the modem. The modem can determine how it wants to time mitigation activities based on the deadline time provided. For example, it does not have to remove carriers that are currently communicating with a base station with a fixed timer schedule.

Figure 1, below, illustrates an example electronic device and elements of the electronic device that supports a dynamic modem mitigation application.

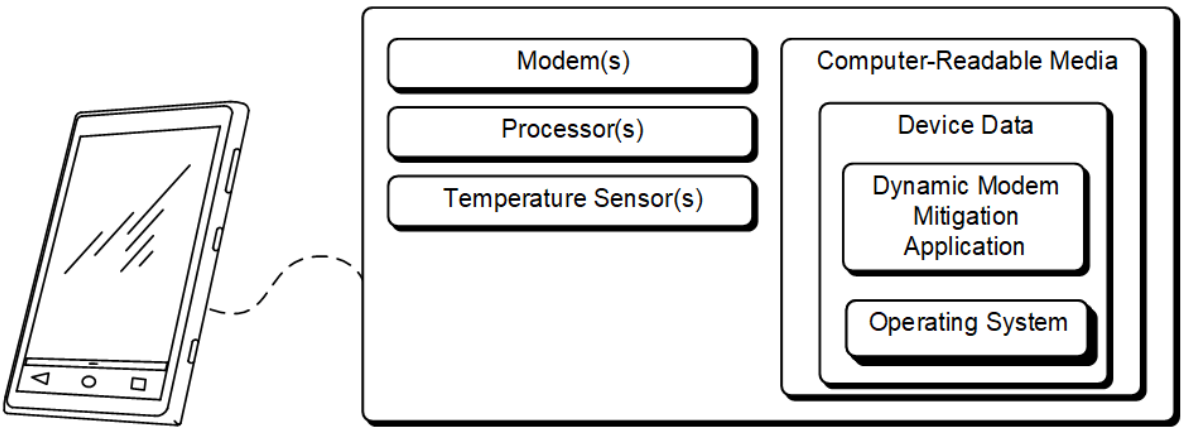

Figure 1

As illustrated, the electronic device is a smartphone. However, other electronic devices (*e.g.*, a tablet, a laptop computer, a wearable device, or the like) can also support the dynamic modem mitigation application described in this publication. The electronic device includes a processor(s), modem(s) (*e.g.,* 4G LTE, 5G NR) for transmitting data to and receiving data from an access point of a wireless network and one or more temperature sensors. The electronic device also includes a computer-readable medium (CRM) that includes device data. The device data includes user data, multimedia data, applications (including a dynamic modem mitigation application), and/or an operating system of the computing device, which are executable by the processor(s) to enable communicating a deadline time for a modem mitigation action by the electronic device. While the dynamic modem mitigation application could be stored within the CRM, other implementations can include any combination of firmware, hardware, and/or software.

The device data includes executable instructions of a dynamic modem mitigation application that can be executed by the processor(s). The dynamic modem mitigation application represents functionality that receives temperature information from one or more sensors, assigns a priority to the thermal situation, calculates a deadline time, and communicates the deadline time to the modem.

An embodiment of dynamic modem mitigation is performed with carrier aggregation. An electronic device may be using several carriers operating in different bandwidths to communicate via a modem with a base station. A temperature sensor (*e.g.*, internal sensor, skin sensor, etc.) of the electronic device determines the electronic device's temperature while the electronic device is communicating with multiple carriers (represented by the arrows), illustrated in Figure 2. Temperature information is provided to the dynamic modem mitigation application.

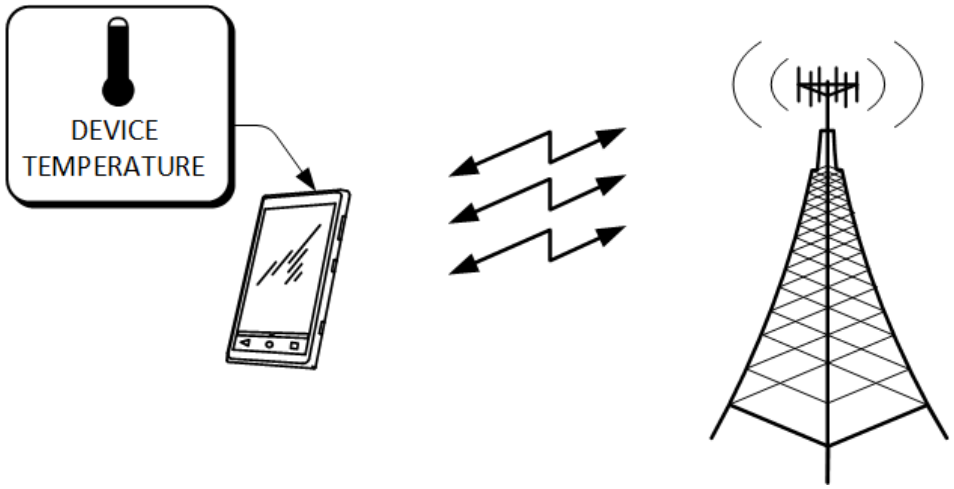

Figure 2

Figure 2 also illustrates a base station. The base station includes transceiver(s) (*e.g.*, a combination of one or more 4G LTE transceivers and/or 5G NR transceivers) to wirelessly communicate with the electronic device. Although Figure 2 illustrates carrier aggregation using specific types of nodes (*e.g.*, a base station) associated with specific types of radio access networks, the following techniques associated with the example environment are non-limiting and can apply to combinations of other types of nodes (*e.g.*, access points) associated with other radio access networks.

The dynamic modem mitigation application receives temperature data from the temperature sensor(s) and assigns a priority to the temperature data based on a threshold and/or a

rate of change to avoid the electronic device exceeding an emergency temperature. The dynamic modem mitigation application communicates, to the modem, a deadline time that the modem must complete an action of removing all but one carrier. One carrier is required to transmit/receive data on. With a long deadline time, the modem can slowly remove carriers, and the electronic device can stay in longer periods of time with more carriers and provide higher throughput. With a shorter deadline time, the modem can quickly drop carriers and better manage the overheating of the electronic device that was increasing at an accelerated rate, illustrated in Figure 3.

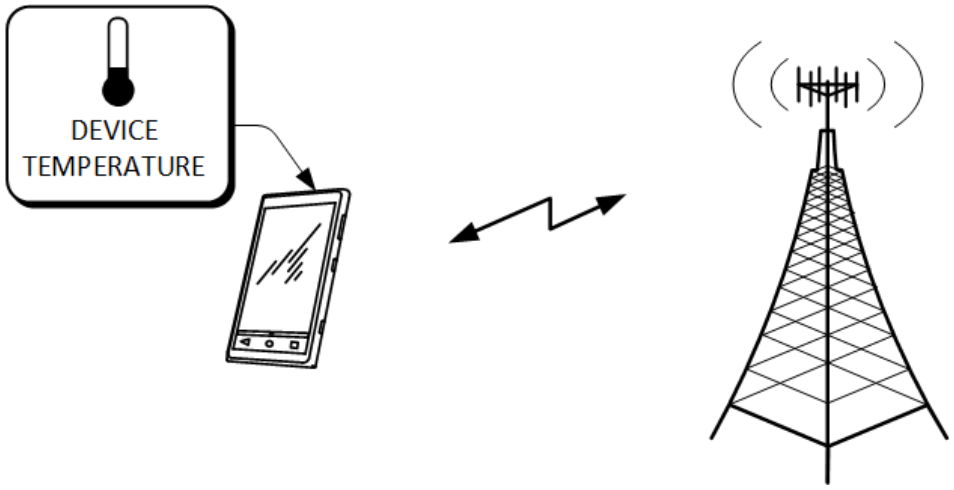

Figure 3

Although the embodiment of carrier aggregation mitigation is described in detail, this method can be applied to other modem mitigation embodiments, including antenna reduction, uplink throttling, and downlink throttling.

References:

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