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OPTIMAL METHOD TO CONTROL MEASUREMENTS OF USER EQUIPMENT BASED ON INDICATIONS OF DEVICE INACTIVITY

Abstract

A multimodal user equipment (UE) monitors various operational conditions indicative of reduced reliance on multimodal capabilities, such as a deactivated display, an immobile UE, low data consumption by background software applications, or a low battery level, and selectively enters a reduced multimodal mode in which the frequency at which measurement operations are performed for various supported radio access technologies (RATs) or radio frequencies is reduced. This results in a reduction in the amount of power and processing bandwidth that otherwise would be consumed if performing these measurement operations at their normal rates.

Background

Mobile phones, cellular-enabled tablet computers, cellular-enabled watches or other wearables, and other UEs often are configured as “multimodal”; that is, capable of supporting multiple radio access technologies (RATs), such as supporting both a Fifth Generation (5G) New Radio (NR) RAT as well as a Fourth Generation (4G) Long Term Evolution (LTE) RAT, or configured to support multiple carrier frequencies for a given RAT, such as supporting both a 2.4 gigahertz (GHz) frequency and a 5 GHz frequency for a Wi-Fi RAT. To provide this multimodal capability, a UE typically performs various measurement operations on each of the supported RATs and on each of the supported carrier frequencies in accordance with a specified schedule. Examples of such measurement operations include measuring received signal strength indicator (RSSI), signal-to-noise ratio (SNR), referenced signal received power (RSRP), and the like. These measurement operations consume significant power and processing bandwidth and thus can impact battery life and the user’s quality of experience.

Description

Figure 1 below illustrates an example configuration of a multimodal UE providing improved battery life and processing throughput based on selective suppression of inter-RAT or intra-RAT measurement operations. Typically, the multimodal UE employs an antenna module for each RAT supported (although in some instances multiple RATs can be supported by the same antenna module), with each antenna module conducting radio frequency (RF) signaling at a corresponding carrier frequency. A transceiver employs transmit and receive channels for each antenna module, as well as providing frequency conversion between RF and IF (Intermediate Frequency). A modem, in turn, operates to convert digital data from an application processor (AP) to an IF signal for transmission, as well as to convert a received IF signal to corresponding digital data for consumption by the AP. The UE further can include various input/output (I/O) devices, such as a display, a touch screen, and the like. The UE typically is powered by one or more batteries or other limited sources of power (e.g., a solar panel).

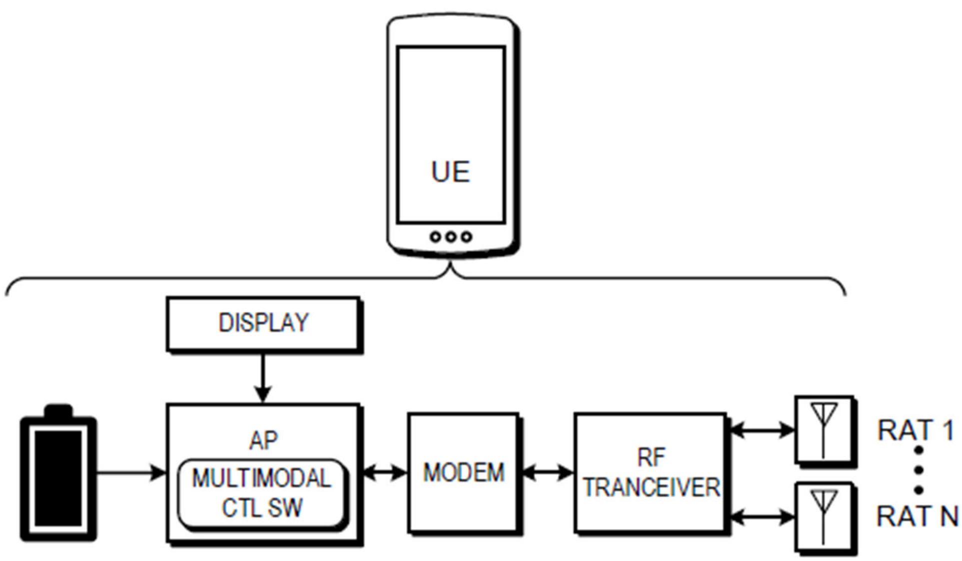

Figure 1 – Multimodal User Equipment

The AP executes various software applications in support of the operation of the UE, including various software applications that utilize at least some of the data bandwidth provided by one or more active RATs at the UE. Further, the AP executes a multimodal control software program (implemented as part of a driver for the modem, for example) that operates to control the execution of various multimodal support operations by the modem and the associated antenna modules. In particular, this control feature includes selectively controlling the measurement operations performed for the various RATs and various frequencies supported by the UE so as to reduce the power consumption and processor bandwidth consumption caused by the measurement operations used to support the multimodal operation.

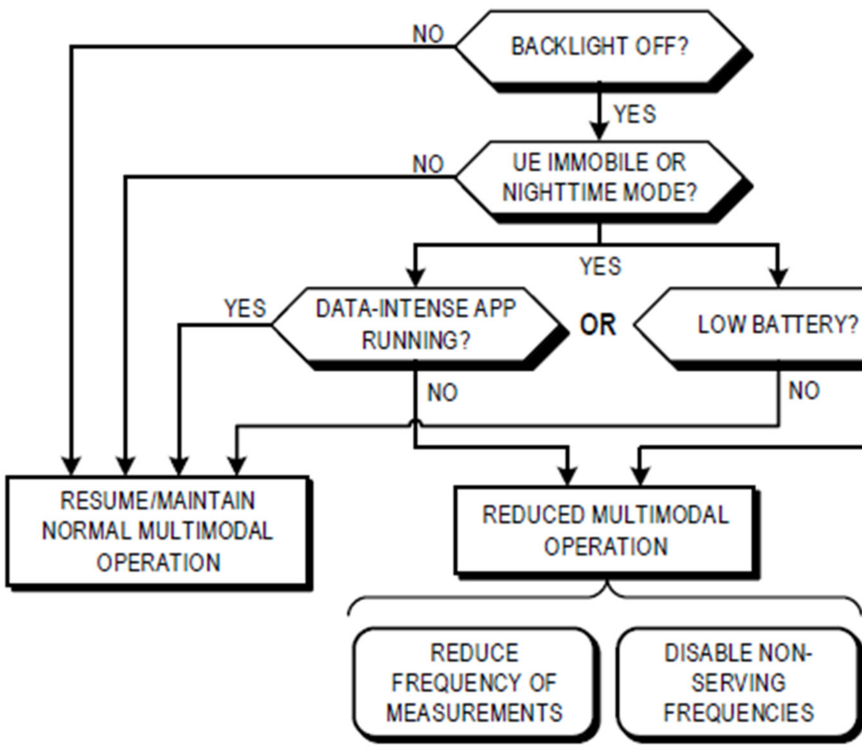

Figure 2 – Selective Multimodal Measurement Suppression Method

Figure 2 above illustrates a flow diagram of a selective multimodal measurement suppression method implemented by the multimodal control software of the multimodal UE. As a general overview, the illustrated method operates to identify scenarios in which full multimodal support is not likely to be needed and thus operates to at least partially suppress the measurement operations that otherwise would be performed to provide full multimodal support. Accordingly, as one determination of whether the UE is in such a scenario, the multimodal control software determines whether the backlight of the display of the UE is off or the display is otherwise deactivated. If not, this is a strong indication that the UE is in use and thus normal multimodal support is maintained. If the backlight is off or the display is otherwise deactivated, the control software also checks to determine whether one or both of the (1) UE is in a nighttime mode or (2) the UE has been immobile for at least a threshold period of time (as indicated based on measurements from, for example, an Inertial Measurement Unit (IMU) or a Global Positioning System (GPS) sensor). If the UE is not in nighttime mode or the UE has been mobile above the threshold, then the normal multimodal mode of operation is maintained. Otherwise, the control software determines whether one or both of the following conditions exist: (1) the UE is executing a software application that is transmitting and/or receiving data via at least one of the antenna modules at a rate above a specified threshold (that is, the software application is “data-intensive”) or (2) the amount of remaining power in the battery of the UE is below a specified threshold (that is, the battery is running “low”). If at least one software application is transmitting/receiving data above the specified threshold and if the battery level is above the threshold, then the control software maintains the UE in the normal multimodal operational mode.

However, if the backlight is off or the display is otherwise deactivated, the UE is immobile or in a nighttime mode and either no software applications are consuming a high data bandwidth or the battery level is low, then the control software controls the modem, transceiver, and appropriate antenna modules to enter into a suppressed measurement mode in which the amount of power and processor bandwidth utilized to conduct measurement operations for multimodal support is reduced. This can be achieved in a number of ways. In one approach, the control software reconfigures the modem via an application programming interface (API) to reduce the frequency of measurement operations for one or more of the RATs and/or one or more of the frequencies supported for a given RAT. For example, rather than conduct an inter-frequency scan every 40 milliseconds (ms) for another Long Term Evolution (LTE) frequency, the scan period can be increased to 400 ms (that is, 10 times slower). Alternatively, or in addition to, reducing the frequency of measurement operations, if serving cell selection criteria are met for a certain cell, the UE is camped or otherwise connected on that cell, and the cell entry criteria are met, the control software can disable one or more of the other non-serving frequencies, whether intra-RAT or inter-RAT. In this way, the current cell connection is maintained but monitoring of other connection options is suppressed through disabling of measurement operations for these other connection options, thereby conserving battery power and processing bandwidth while maintaining the current cell connection.

While the UE is in the reduced multimodal operation mode, the control software continues to monitor for changes in the measurement suppression criteria, such as by monitoring the display, the UE mobility, data use by executing software applications, and battery level, and when the condition of one or more of these monitored aspects changes in a manner that supports normal multimodal operation, the control software configures the modem to exit the reduced multimodal operation mode and to resume normal multimodal operation with the performance of more frequent measurement operations.

References:

1. U.S. Patent Application Publication No. US20130225169A1, entitled “Method in a device, and a wireless device” and filed on 7 June 2012, the entirety of which is incorporated by reference herein.
2. U.S. Patent Application Publication No. US20120034917A1, entitled “Method of frequency search” and filed on 20 April 2009, the entirety of which is incorporated by reference herein.