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Recommended Citation

Chen, Edison, "Reducing Modem Power Consumption While In An Out-of-Service Condition By Suspending Universal Integrated Circuit Card (UICC) Operation", Technical Disclosure Commons, (December 21, 2021) https://www.tdcommons.org/dpubs_series/4798



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Reducing Modem Power Consumption While In An Out-of-Service Condition By Suspending Universal Integrated Circuit Card (UICC) Operation

Abstract

A user equipment (UE) employs a Universal Integrated Circuit Card (UICC) suspend algorithm when the UE is in an out-of-service (OOS) condition. When a modem of the UE enters an OOS sleep mode, the modem executes the UICC suspend algorithm to reduce activity at the UICC and conserve power. When the modem wakes up for network signal scanning, the modem executes a UICC resume algorithm to process any incoming commands. The UE thereby conserves power while in the OOS condition.

Background

Under the UICC-Terminal Interface specification promulgated by the European Telecommunications Standards Institute, a UE is required to send a status command to a UICC Subscriber Identity Module (SIM) at frequent intervals. The interval (e.g., 28 seconds) between the status commands is requested from the SIM. The terminal can use a UICC suspension algorithm to suspend the UICC when access is not required for a long period of time, thereby reducing overall power consumption. The suspension duration can be provided by the UE via a SIM Application Toolkit (STK) command. However, the UE is typically only able to process the UICC suspension algorithm in specific modes, such as the Extended Discontinuous Reception (eDRX) mode, the Power Saving Mode (PSM), and the Mobile Initiated Connection Only (MICO) mode. Outside of these modes, the UICC may remain in an idle state, consuming a relatively large amount of power. For example, when the UE is in an out-of-service condition, the UE does not receive any STK commands from the network, so the modem must periodically wake up for status reporting.

Description

Using the technique described herein, when a UE modem is to enter a long period in a low power mode (e.g., a sleep mode) while the UE is out of service, the modem executes the UICC suspend algorithm to reduce power consumption. When the modem wakes up from the low power mode to perform network signal scanning, the modem executes a UICC resume algorithm in order to process any incoming STK command.

The process for initiating the UICC suspend algorithm is illustrated at Figure 1, below:

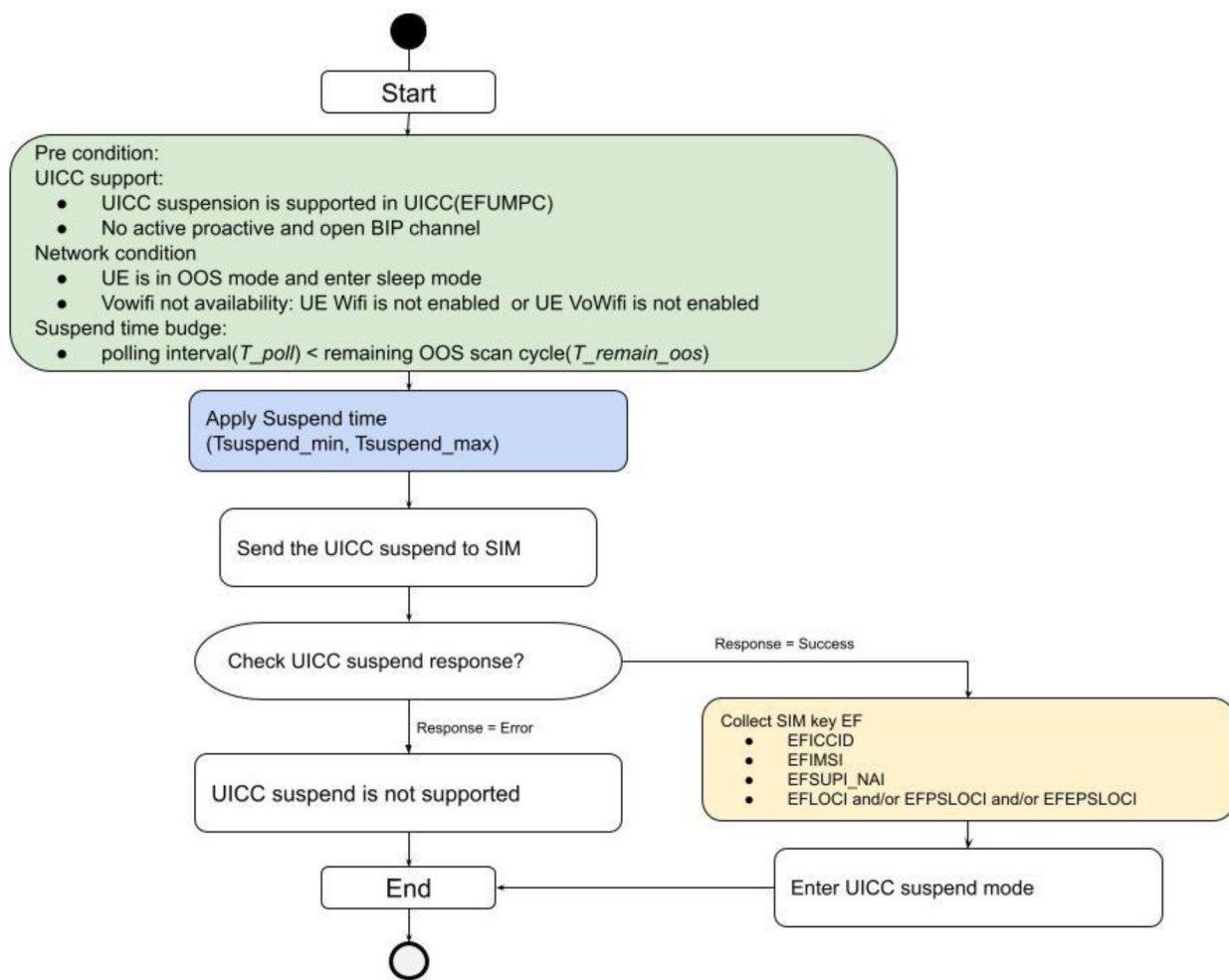


Figure 1

As illustrated, the modem first determines if the pre-conditions for executing the UICC suspend algorithm are met. In particular, the modem determines if the following sets of conditions are met: 1) UICC support conditions; 2) network conditions; and 3) a suspend time condition. If any of these conditions are not met, the modem does not execute the UICC suspend algorithm.

The modem determines if the UICC support conditions are met by 1) determining if the UICC maximum power consumption (EFUMPC) of the UE supports UICC suspension, and 2) determining that there is no active and open bearer independent (BIP) channel. If either of these conditions are not met, then the UICC support conditions are not met.

The modem determines if the network conditions are met by 1) determining if the UE is in OOS mode and is to enter sleep mode, and 2) voice-over-Wi-Fi (Vowifi, also sometimes referred to as VoWiFi) is not available, either because a Wi-Fi connection is not available or because voice-over-Wi-Fi is not enabled at the UE. If both of these conditions are met, the modem determines that the network conditions are satisfied.

For the suspend time condition, the modem determines if the polling interval for the mode is less than the remaining OOS scan cycle. If so, the modem determines that the suspend time condition is satisfied.

If the above conditions are satisfied, the modem first applies the suspend time, then sends the UICC suspend command to the SIM that is to execute the UICC suspend algorithm. In response, the SIM initiates execution of the UICC suspend algorithm, and provides the modem with one of two responses: a success response, if the UICC suspend algorithm was executed successfully, or an error, indicating that the SIM is not able to execute the UICC suspend

algorithm. In response to the error indication, the modem determines that the UICC suspend condition is not supported.

In response to the success indication, the modem collects and stores information from the SIM Elementary Files (EF), including the UICC identification number (EFICCID), the International Mobile Subscriber Identity (EFIMSI), the Subscription Permanent Identifier as Network Access Identifier (EFSUPI_NAI), and one or more of the Location Information (EFLOCI), the Packet Switched Location Information (EFPSLOCI), and the Evolved Packet System Location Information (EFEPSLOCI). The UICC then enters the suspend mode, conserving power while the UE is in the OOS condition.

The process for returning the UICC to the idle mode from the suspend mode is illustrated at FIG. 2, below:

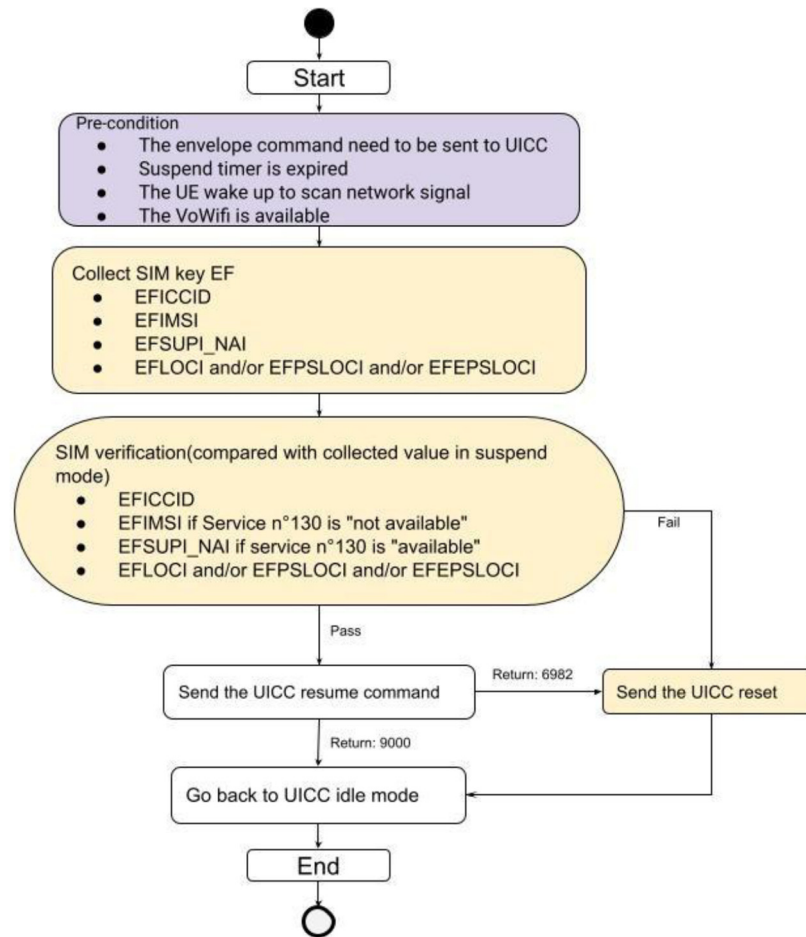


Figure 2

As illustrated, the modem first determines if any of the pre-conditions for exiting the UICC suspend mode are met. In particular, the modem determines if one or more of the following conditions are met: 1) an envelope command needs to be sent to the UICC; 2) the suspend timer for the UICC suspend mode has expired; 3) the UE is exiting sleep mode to scan for a network signal; and 4) voice-over-Wi-Fi is available. If any of these conditions are met, the modem causes the UICC to exit the suspend mode.

To have the UICC exit the suspend mode, the modem first retrieves a number of EF files from the SIM, including the EFICCID, the EFIMSI, the EFSUPI_NAI, and one or more of the EFILOCI, EFPSLOCI, and EFEPSLOCI. The modem then compares these retrieved EF files

with the corresponding files that were collected and saved prior to the UICC entering the suspend mode, as described above. If there is a mismatch in any of the files, the modem identifies a failure and sends a reset command to the UICC. After reset, the UICC is placed in the idle mode.

If the EF files match, the modem sends a resume command to the UICC. In response, the UICC sends a status code of either 9000, indicating normal operation, or 6982, indicating a security status error. In response to indication of an error, the modem sends a reset command to the UICC. After reset, the UICC is placed in the idle mode. In response to an indication of normal operation, the UICC is placed in the idle mode.

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