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Reducing Modem Power Consumption While in an Out-of-Service Condition by Synchronizing Network Scanning and SIM Polling

Edison Chen

REDUCING MODEM POWER CONSUMPTION WHILE IN AN OUT-OF-SERVICE CONDITION BY SYNCHRONIZING NETWORK SCANNING AND SIM POLLING

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 exits an OOS sleep mode and enters an active mode (sometimes referred to as "waking up") for network signal scanning, the UE modem also sends a polling message (e.g., a status report) to one or more UICC Subscriber Identity Modules (SIMs) of the UE. In some cases, the UE modem also negotiates a polling interval with the one or more SIMs. By synchronizing the sending of the polling message with the exiting of sleep mode for network signal scanning, the UE reduces the overall number of times the sleep mode is exited. The UE thereby increases the time spent in the sleep mode, and thus conserves more power while in the OOS condition.

Background

Under the UICC-Terminal Interface specification promulgated by the European Telecommunications Standards Institute (ETSI), a UE is required to send status commands to a UICC SIM at frequent intervals. The interval (e.g., 28 seconds) between status commands is requested from the SIM. The UE can use a UICC suspension algorithm to suspend the UICC SIM when access is not required for a long period of time, thereby placing a modem of the UE in a sleep mode and 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 and the UE modem may remain in an idle state, consuming a relatively large amount of power. Furthermore,

when the UE is in an OOS state, the UE modem will wake up (that is, exit the sleep mode) to send periodic status reporting (also referred to as polling) messages to the SIM.

Description

Using the technique described herein, when a UE modem exits an OOS sleep mode and wakes up for network signal scanning, the UE modem sends a polling message (e.g., a status report) to the SIMs of the UE. That is, the sending of the polling message is synchronized with the UE modem exiting and performing network signal scanning. In contrast, conventional UE designs do not synchronize sending of polling messages with the periods of network signal scanning, causing the UE modem to wake up at different times for network scanning and for polling. Thus, by synchronizing the sending of the polling message, as well as any negotiation of the polling interval, with the UE modem exiting the sleep mode and performing network signal scanning, the number of times the UE modem exits the OOS sleep mode is reduced, thereby conserving power.

Table 1 illustrates an example of a conventional UE modem exiting the OOS sleep mode for both network scanning and polling in an unsynchronized fashion:

Time	T0	T1	T2	…	T23	T24	…	T29
Modem	Sleep	Wake	Sleep		Wake	Sleep		Wake
SIM		Send poll			OOS timeout, network scan			Send poll

Table 1

In this example, at times T1 and T29, the UE modem exits the sleep mode to send a polling message to a UE SIM. In addition, at time T23 the UE modem exits the sleep mode to perform

network scanning. Thus, in the example of Table 1, the UE modem exits the sleep mode three times between time T0 and time T29.

Table 2 illustrates an example of a UE modem using the disclosed techniques to exit the OOS sleep mode for both network scanning and polling in an unsynchronized fashion:

Time	T0	T1	T2	…	T23	T24	…	T51
Modem	Sleep	Wake	Sleep		Wake	Sleep		Wake
SIM		Send poll			OOS timeout, network scan, send poll			Send poll

Table 2

In this example, at time T1, the UE modem exits the sleep mode to send a polling message to a UE SIM. At time T23 the UE modem exits the sleep mode to perform network scanning, and also sends a polling message to the UE SIM. Accordingly, the UE modem does not send another polling message to the UE SIM until time T51, rather than at time T29 as in the example of Table 1. Over time, synchronizing the network scanning and sending of polling messages in this way reduces the overall number of times that the UE modem exits the sleep mode, thus reducing power consumption by the UE.

In some cases, the UE modem and the UE SIM are configured to negotiate a polling interval that establishes the interval between UE polling messages. The UE modem and UE SIM can therefore negotiate an extended interval (relative to a specified default interval), further reducing the number of times the UE modem exits the OOS sleep mode, and thus further reducing power consumption by the UE. An example is illustrated at Table 3:

Time	T0	T1	T2	…	T23	T24	…	T83
Modem	Sleep	Wake	Sleep		Wake	Sleep		Wake
SIM		Send poll			OOS timeout, network scan, send poll, negotiate poll interval			Send poll

Table 3

In this example, at time T1, the UE modem exits the sleep mode to send a polling message to a UE SIM. At time T23 the UE modem exits the sleep mode to perform network scanning, sends a polling message to the UE SIM, and also negotiates a new poll interval with the UE SIM. Based on the new poll interval, the UE modem does not send another polling message to the UE SIM until time T83, rather than at time T29 as in the example of Table 1, or time T51 as in Table 2. Thus, relative to the example of Table 2, the overall number of times that the UE modem exits the sleep mode is further reduced, thus conserving more power at the UE.

Figure 1 illustrates an example process of a UE sending a polling message when the UE exits the OOS sleep mode:

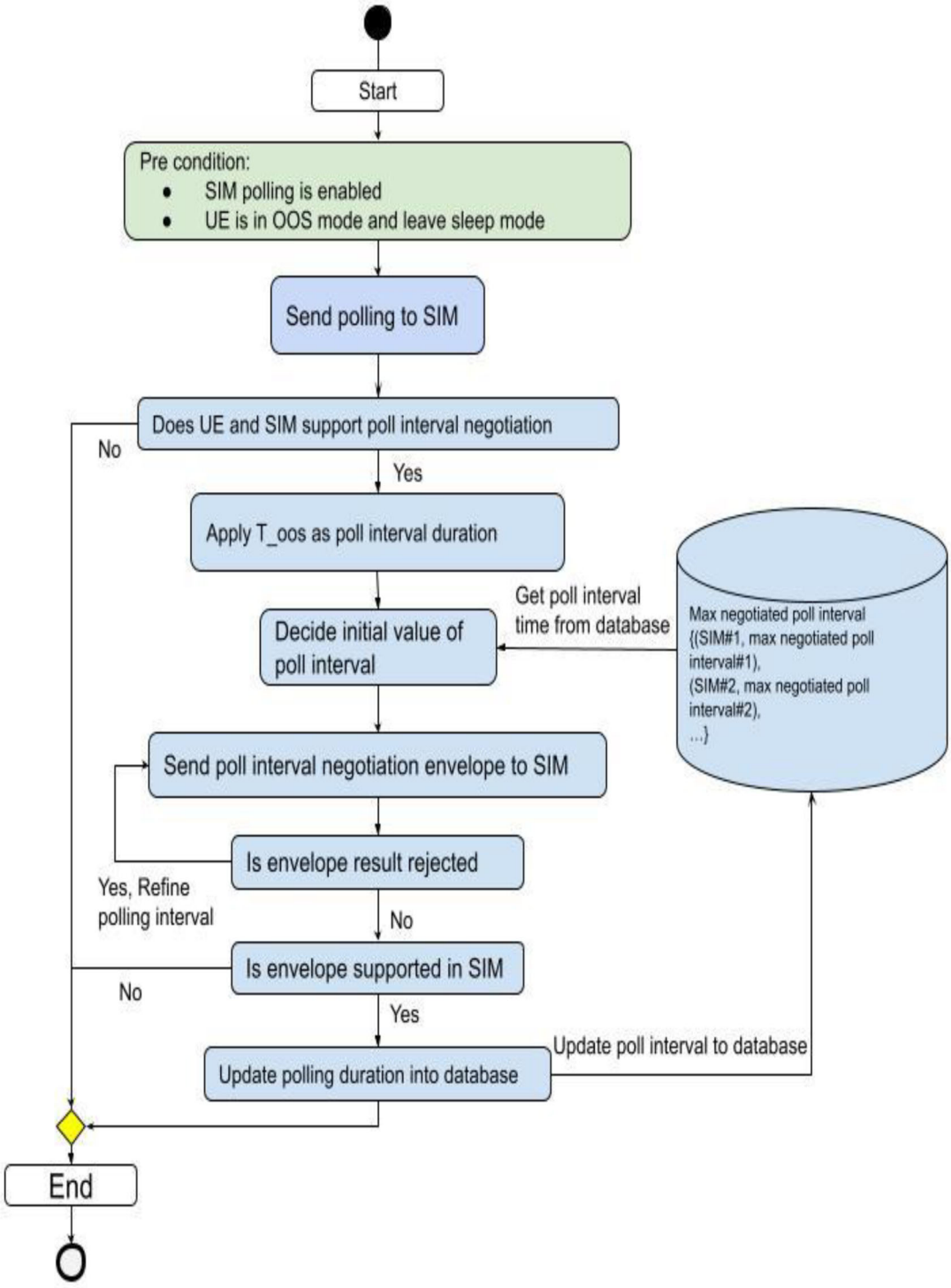

Figure 1

There are two preconditions for implementing the depicted process: SIM polling must be enabled at the UE, and the UE must be in OOS mode and be exiting the OOS sleep mode for network

signal scanning. When these two preconditions are met, the UE modem sends a polling message to the UE SIM. The UE then determines whether both the UE and the SIM support poll interval negotiation. If not, the process ends, and the UE modem returns to sleep mode.

If both the UE and the SIM support poll interval negotiation, the UE first applies a default value (designated T_oos) as the poll interval duration. The UE then determines an initial value for the poll interval duration by first obtaining the highest previously negotiated interval for the SIM from a stored database. The UE then selects the higher of the retrieved value and the T_oos value as the initial value for the poll interval duration.

The UE sends the selected poll interval duration to the SIM. If the SIM rejects the selected poll interval duration, the UE changes the poll interval duration value, such as by reducing the value by a specified amount. The UE continues to adjust and send the poll interval duration until the duration is accepted by the SIM or the UE determines that the SIM will not negotiate a poll interval duration higher than T_oos. If the UE determines that the SIM will not negotiate a poll interval duration value higher than T_oos, the process ends. If the SIM accepts a poll interval duration value higher than T_oos, the UE updates the database with the accepted poll interval duration and uses the accepted poll interval duration to determine when to send polling messages to the SIM. The UE thus synchronizes the negotiation of the poll interval duration with the UE modem exiting sleep mode to perform network scanning. This synchronization reduces the number of times the UE modem is required to exit the sleep mode, thus conserving UE resources, including power.

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