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INTELLIGENT SIM SWITCHING IN A MULTI-SIM COMPUTING DEVICE

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ABSTRACT

A system is described that enables a computing device (e.g., a mobile phone, a tablet computer, a laptop computer, etc.) to intelligently determine whether to move a data connection from a default data subscriber identity module (DDS) to a non-default data subscriber identity module (non-DDS) when initiating a voice call or during an on-going voice call on the non-DDS in a multiple subscriber identity module (multi-SIM) computing device based on a current state of the computing device. The current state of the computing device may be determined based on various contextual signals, including data usage for each application on the device, the number of foreground applications, the number of background applications, data tethering state, voice call characteristics, connected peripherals, computing device screen state, and/or sensor data generated by one or more sensors (e.g., proximity sensors, near-field microwave sensors, radar, capacitive sensors, etc.) of the computing device. The computing device may analyze these contextual signals to determine a current state of the device and may selectively move the data connection from the DDS to the non-DDS based on this state information.

DESCRIPTION

Computing devices may contain more than one SIM that each provides users with access to a different mobile network. While a multi-SIM computing device may be equipped with more than one SIM, the device may include only one transceiver. In such situations, the computing device may only operate using one mobile network at a time such that the computing device is not able to connect to other mobile networks while connected to the one mobile network. The

SIM selected for data use is referred to herein as the Default Data SIM (DDS), and SIMs not selected for data use are referred to herein as Non-Default Data SIMs (non-DDSs).

In multi-SIM computing devices with only one transceiver, during a voice call on a non-DDS, the non-DDS is using the transceiver to transmit and receive radio frequency (RF) signals. As such, the DDS cannot also use the transceiver to provide data service to the user. Thus, the user may not have data service during an on-going voice call on the non-DDS. While the computing device may shift data connection from the DDS to the non-DDS when a voice call is initiated on the non-DDS, switching the data connection may disrupt any active data connection (e.g., due to a change in IP address).

Rather than automatically switch data connection from the DDS to the non-DDS when a voice call is initiated (whether an incoming or outgoing call) on the non-DDS, techniques of this disclosure may enable a multi-SIM computing device to intelligently switch data connection from the DDS to the non-DDS based a current state of the multi-SIM computing device. By intelligently switching data connection from the DDS to the non-DDS, data connection disruptions may be reduced while still trying to maximize data usage on the DDS.

Figure 1, below, is a block diagram illustrating an example multi-SIM computing device. In the example of FIG. 1, computing device 100 represents an individual multi-SIM computing device that includes two SIMs. While shown with two SIMs, computing device 100 is not so limited and may include three or more SIMs. Examples of computing device 100 include a mobile phone, a tablet computer, a laptop computer, a desktop computer, a server, a mainframe, a set-top box, a television, a wearable device (e.g., a computerized watch, a computerized eyewear, a computerized glove, etc.), a home automation device or system (e.g., an intelligent thermostat or a home assistant device), a personal digital assistant (PDA), a gaming system, a media player, an e-book reader, a mobile television platform, an automobile navigation or infotainment system, or any other type of multi-SIM computing device.

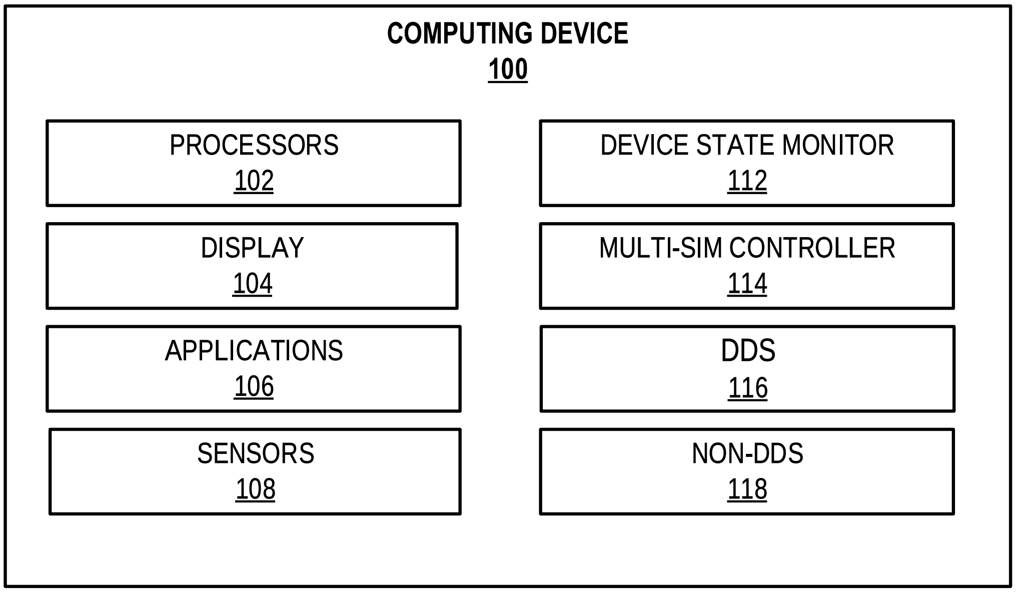

Figure 1

Computing device 100 includes processors 102, display 104, applications 106, sensors 108, device state monitor 112, multi-SIM controller 114, DDS 116, and non-DDS 118. Applications 106 can be executed by processors 102 to provide various functions (e.g., email, word processing, web browsing, text messaging, navigation, photography, etc.). Display 104 may be a liquid crystal display (LCD), thin-film transistor display (TFT), organic light-emitting diode display (OLED), or other suitable displays. Sensors 108 may include proximity sensors, near-field microwave sensors, capacitive sensors, radar, or other suitable sensors. Device state monitor 112 may monitor data usage of applications 106, number of foreground applications, number of background applications, the last active application (i.e., the application before the dialer took over as the last active application) with data usage, priority level of applications with data usage, applications with periodic usage of data and upcoming timer expiry, data tethering state, voice call characteristics, connected peripherals, computing device screen state, and/or sensor data generated by sensors 108 (e.g., proximity sensors, near-field microwave sensors, radar, capacitive sensors, etc.) of the computing device 110, and may provide such information to multi-SIM controller 114.

Multi-SIM controller 114 may assign a state to computing device 110 based on the received information, and may selectively move a data connection from DDS 116 to non-DDS 118 based on the assigned state. In general, multi-SIM controller 114 automatically moves a data connection from the DDS to the non-DDS without further delay when computing device 100 is assigned with a “switch immediately” state. In instances where the computing device is assigned with a “delay switch” state, multi-SIM controller 114 may delay moving the data connection. However, if the computing device is assigned with an “avoid switch” state, multi-SIM controller 114 may not move the data connection at all.

In one example, a user is interacting with a mapping application executing at computing device 100. The mapping application may have a particular priority level, be periodically using data (e.g., to retrieve updated map information, to determine routing information, etc.) via a data connection established using the DDS, and may be the foreground application when computing device 100 receives an incoming phone call on the non-DDS. Device state monitor 112 captures this information and provides the information to multi-SIM controller 114 in response to the incoming phone call. Multi-SIM controller 114 may analyze this information and determine a current state for computing device 100. For purposes of this example, the mapping application is a high priority application. Given this information, multi-SIM controller 114 may assign “switch immediately” state to computing device 100 and may move the data connection from the DDS to the non-DDS for the mapping application without further delay. However, in instances where the mapping application is a lower priority application, multi-SIM controller 114 may instead assign a “delay switch” state to computing device 100 and may delay moving the data connection until a later time (e.g., to reduce data usage on the non-DDS).

In another example, a user is interacting with a music application executing at computing device 100 to download audio files to the device. The music application may be in the process of receiving the audio files over the internet when computing device 100 initiates an outgoing phone call on the non-DDS. Device state monitor 112 captures this information and provides the information to multi-SIM controller 114 in response to the outgoing phone call on the non-DDS. Multi-SIM controller 114 may analyze this information and determine the music application is actively using at least one data connection on the DDS. Based on this information, multi-SIM controller 114 may assign an “avoid switch” state to computing device 100 and may not move the data connections at all. By keeping data connection on the DDS, multi-SIM controller reduces the risk of interrupting the process of downloading audio files and the data connection.

As another example, computing device 100 may be connected with a car audio system. An email application executing at computing device 100 may run in the background when computing device 100 receives a voice call on the non-DDS. Device state monitor 112 may capture this information and provide the information to multi-SIM controller 114 in response to the voice call received on the non-DDS. Multi-SIM controller 114 may analyze this information and determine computing device 100 is connected with a hands-free car accessory. Based on this information, multi-SIM controller 114 may assign a “delay switch” state to computing device 100 and may delay moving the data connection until a later time (e.g., until computing device 100 is not connected with a hands-free accessory).

In various instances, computing device 100 may use sensors 108 to detect various contextual signals and may selectively move the data connection from the DDS to the non-DDS based on the various detected contextual signals.

In examples where sensors 108 include a proximity sensor, multi-SIM controller 114 may determine whether to switch the data connections based at least in part on whether the proximity sensor detects an object. For example, a user may be interacting with a gaming application executing at computing device 100. When computing device 100 receives an incoming phone call on the non-DDS, the user may hold the computing device close to the user's face to answer the call and leave the gaming application running in the foreground. The proximity sensor may detect that an object is in close proximity (e.g., the user is holding the device close to the skin) and may transmit this information to device state monitor 112. Device state monitor 112 may receive and provide the information to multi-SIM controller 114. Based on the proximity sensor detecting the object, multi-SIM controller 114 may assign a "delay switch" state to computing device 100 and may delay moving the data connection until a later time (e.g., until the user is not holding computing device 100 close to the skin).

In examples where sensors 108 include a radar sensor, multi-SIM controller 114 may determine whether to switch the data connections based at least in part on whether a user is within a viewable range or otherwise in the general proximity of computing device 100. For example, a user with hearing loss may pair a Bluetooth® hearing aid device with computing device 100. When computing device 100 receives an incoming phone call on the non-DDS, the user may answer the phone call received on computing device 100 remotely by using the hearing aid. Several applications with data usage may run in the background when computing device 100 receives the call. In such situations, the radar sensor may not detect an object nearby computing device 100 and may transmit this information to device state monitor 112. Device state monitor 112 may receive and provide the information to multi-SIM controller 114 in response to the call received on the non-DDS. Based on this information, multi-SIM controller 114 may assign a “delay switch” state to computing device 100 and may delay moving the data connection until a later time (e.g., until the user is in proximity to computing device 100).

Figure 2, below, is a table diagram illustrating examples of contextual signals detected from either software or hardware and states determined based on their respective contextual signals.

Input	Condition	Outcome
Priority application	Running / active	Switch immediately
Proximity sensor	Device close to skin	Delay switching
Any application	FTP active	Avoid switching
Soli status	User not in proximity	Delay switching
Connected accessories	Handsfree	Delay switching
Any application (other than dialer)	Running in foreground	Switch immediately
Speakerphone	On	Delay switching

Figure 2

By intelligently moving data connections from DDS 116 to non-DDS 118 based on one or more detected contextual signals, computing device 100 may reduce data connection disruptions to critical applications while still trying to maximize data usage on DDS 116.

It is noted that the techniques of this disclosure may be combined with any other suitable technique or combination of techniques. As one example, the techniques of this disclosure may be combined with the techniques described in U.S. Patent Application Publication

2015/0094071A1. Such a combination may be made for any suitable purpose, including, but not limited to, intelligently determine switching data from a DDS to a non-DDS during an on-going voice call on the non-DDS in a multi-SIM computing device based on received contextual signals.