A multiple-subscriber identity module (multi-SIM) multi-standby communication device comprises a single radio resource unit shared by a plurality of virtual modems (VMs), each uniquely associated with a single one of a plurality of SIM cards. The access to radio resources in the single radio resource unit is controlled via a virtual modem controller (VMC). The VMC collects performance metrics such as requested service type and signal quality associated with each of the VMs. A VM is selected based on the collected performance metrics to perform a requested service. A serving VM is switched among the VMs based on the collected performance metrics. VM capabilities are dynamically configured based on the collected performance metrics. According to the collected performance metrics such as associated navigation information and requested service type, one or more VMs may be turned on or off, and certain VM capabilities may be enabled or disabled to save resources.
Virtual modern controller (VMC) (Multiple SIM cards inserted) → 502 → 504
Select one of VMs associated with the inserted multiple SIM cards as a serving VM for a requested service → 506
Perform the requested service utilizing the selected serving VM → 508
Collect performance metrics for the serving VM and other VMs → 510
One or more VMs associated with better performance metrics? → 510 → 512
Yes → Select a VM corresponding to the best performance metrics as a serving VM to serve the requested service
No → Perform the requested service utilizing the selected serving VM → 508

FIG. 5
Virtual modem controller (VMC) → Multiple SIM cards inserted

Track and collect performance metrics for VMs associated with the inserted multiple SIM cards → Configure capabilities of the corresponding VMs based on the collected performance metrics

user service request type → Network availability → QoS → Signal quality → Navigation information
METHOD AND SYSTEM FOR DYNAMICALLY SELECTING AND CONFIGURING VIRTUAL MODEMS (VMS) BASED ON PERFORMANCE METRICS IN A MULTI-SIM MULTI-STANDBY COMMUNICATION DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

[0001] This patent application makes reference to, claims priority to and claims the benefit from U.S. Provisional Patent Application Ser. No. 61/261,922 filed on Nov. 17, 2009.
[0002] This application also makes reference to:
[0006] U.S. application Ser. No. 12/819,014 filed on Jun. 18, 2010, and
[0008] Each of the above stated applications is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0009] Certain embodiments of the invention relate to communication systems. More specifically, certain embodiments of the invention relate to a method and system for task-level access arbitration between virtual modems in a multi-SIM multi-standby communication device.

BACKGROUND OF THE INVENTION

[0010] With the development of mobile communication systems, mobile devices may utilize various mobile communication techniques such as, for example, global system for mobile communications (GSM), Universal Mobile Telecommunications System (UMTS), Long Term Evolution (LTE) network and wireless local area network (WLAN) to receive desired services. In instances where a mobile device subscribes to a communication network, subscriber information may be required to identify the mobile device to the network for various network services such as authentication, accounting, billing and security services. The subscriber information may be stored in a subscriber identity module (SIM) card inserted in the mobile device. A SIM card is a card or a chip installed in the mobile device providing information to identify the subscriber carrying the mobile device to networks.

[0011] Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

[0012] A method and/or system for dynamically selecting and configuring virtual modems (VMs) based on performance metrics in a multi-SIM multi-standby communication device, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

[0013] These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0014] FIG. 1 is a diagram illustrating an exemplary communication system that is operable to dynamically select and configure virtual modems (VMS) based on performance metrics in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention.

[0015] FIG. 2 is a block diagram illustrating an exemplary multi-SIM multi-standby communication device that is operable to dynamically select and configure virtual modems (VMS) based on performance metrics, in accordance with an embodiment of the invention.

[0016] FIG. 3 is a block diagram illustrating an exemplary multi-instance virtual modem approach to concurrently handle multi-instance tasks on a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention.

[0017] FIG. 4 is a flow chart illustrating exemplary steps that may be utilized by a virtual modem controller to select a virtual modem (VM) based on performance metrics to perform a requested service in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention.

[0018] FIG. 5 is a flow chart illustrating exemplary steps that may be utilized by a virtual modem controller to switch a serving virtual modem (VM) based on performance metrics to perform a requested service in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention.

[0019] FIG. 6 is a flow chart illustrating exemplary steps that may be utilized by a virtual modem controller to configure virtual modem (VM) capabilities based on performance metrics in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention.

[0020] FIG. 7 is a flow chart illustrating exemplary steps that may be utilized by a virtual modem controller to turn on/off a virtual modem (VM) based on performance metrics in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Certain embodiments of the invention may be found in a method and system for dynamically selecting and configuring virtual modems (VMs) based on performance metrics in a multi-SIM multi-standby communication device. In various embodiments of the invention, a multiple-subscriber identity module (multi-SIM) multi-standby communication device comprises a single radio resource unit providing layer 1, namely, physical layer (PHY), and RF, for example, functionalities. A virtual modem architecture (VMA) is deployed on the single radio resource unit to handle operations in a multi-standby mode. The VMA comprises a plurality of virtual modems (VMS), a virtual modem framework (VMF) and a virtual modem controller (VMC). Each of the plurality of VMs is uniquely associated with a single one of a plurality of
SIM cards that are coupled to the multi-SIM multi-standby communication device. The VMC may be operable to manage and/or control the usage of available radio resources in the single radio resource unit for each of the plurality of VMs. For example, the VMC may collect performance metrics associated with each of the plurality of VMs to dynamically select a VM to perform a requested service. The collected performance metrics may comprise, for example, requested service type, network availability, quality of service (QoS), signal strength and/or navigation related information such as location, velocity and/or time. The VMC may switch a serving VM to another one of the plurality of VMs based on the collected performance metrics to continue the requested service. VM capabilities such as 2G/3G service support may be dynamically configured based on the collected performance metrics. The VMC may be operable to enable or disable at least a portion of VM capabilities based on the collected performance metrics. For example, certain VM capabilities such as short messaging service (SMS) and/or cell broadcasting service support may be enabled or disabled based on requested service type and/or navigation information associated with the multi-SIM multi-standby communication device. The VMC may turn on or off one or more VMs based on the collected performance metrics such as requested service type and/or navigation information associated with the multi-SIM multi-standby communication device. [0022] FIG. 1 is a diagram illustrating an exemplary communication system that is operable to dynamically select and configure virtual modems (VMs) based on performance metrics in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention. Referring to FIG. 1, there is shown a communication system 100. The communication system 100 comprises a plurality of mobile devices 110, of which multi-SIM multi-standby communication devices 112-116 are illustrated, a UMTS network 130, a Long Term Evolution (LTE) network 140, and a GSM network 150. [0023] A multi-SIM multi-standby communication device such as the multi-SIM multi-standby communication device 112 may comprise suitable logic, circuitry, interfaces and/or code that are operable to communicate with various network services such as authentication, billing and/or security with a plurality of communication access networks such as, for example, the UMTS network 130, the LTE network 140, and the GSM network 150. Multiple SIM cards such as SIM cards 112a may be coupled or connected with the multi-SIM multi-standby communication device 112 through one or more SIM card sockets or connections. The multi-SIM multi-standby communication device 112 may read or retrieve SIM identification information from the SIM cards 112a via the one or more SIM card sockets or connections. The retrieved SIM identification information may be stored within the multi-SIM multi-standby communication device 112 to support various network services such as authentication, billing and security whenever needed. In this regard, the multi-SIM multi-standby communication device 112 may be configured to activate the retrieved SIM identification information on one SIM card at a time, or on multiple SIM cards at the same time depending on implementation and/or device configuration. In instances where the retrieved SIM identification information is activated on one SIM card at a time, the multi-SIM multi-standby communication device 112 may operate in a single-standby mode. In instances where the retrieved SIM identification information is activated on two or more SIM cards at the same time, the multi-SIM multi-standby communication device 112 may operate in a multi-standby mode. In this regard, the multi-SIM multi-standby communication device 112 in a multi-standby mode may be operable to support multiple subscriptions at the same time. [0024] A user of the multi-SIM multi-standby communication device 112 may be allowed to utilize multiple numbers, multiple different service plans and/or network carriers at the same time whenever the multi-SIM multi-standby communication device 112 is in a multi-standby mode. Each of the multi-SIM multi-standby communication devices 112-116 may utilize a single radio resource unit for Layer 1, namely, physical layer (PHY), DSP and RF functionalities. For example, the single radio resource units 112c-116c may comprise suitable logic, circuitry, interfaces and/or code that may be integrated into the multi-SIM multi-standby communication devices 112-116, respectively, to provide PHY, DSP and RF functionalities for desired services. [0025] U.S. application Ser. No. 12/816,782, which is filed on Jun. 16, 2010, provides detailed description of a Virtual Modem Architecture (VMA) which may be adopted over a single baseband and DSP chiplet to support a multi-standby mode on a multi-SIM multi-standby communication device, and is hereby incorporated herein by reference in its entirety. [0026] The multi-SIM multi-standby communication device 112 may deploy a VMA 112b over the single radio resource unit 112c to support operations in a multi-standby mode. The VMA 112b may be configured to concurrently handle multiple tasks or instances over the single radio resource unit 112c. Each of tasks or instances is associated with one of the multiple SIM cards 112a. A task may also be called an instance of a process. An air interface protocol stack and/or a Common Application Programming Interface (CAPI) module may comprise multiple tasks. A collection of air interface protocol stack tasks and/or CAPI tasks associated with a single SIM card together with appropriate physical layer (PHY), DSP functionalities, and/or RF functionalities supported by the single radio resource unit 112c is referred to as a Virtual Modem (VM). Each VM in the VMA may be assigned to handle instances related to one of the multiple SIM cards 112a. A VM may be placed or may operate in one of a plurality of VM states, comprising, for example, an active state, an idle state or a suspended state. In an active state, radio resources are assigned to the VM and a valid or active connection between a VM and an associated cell is established for data and/or voice communication. The VM may be allowed to utilize radio resources available in the single radio resource unit 112c to communicate or support services related to a specific SIM card. In an idle state, no valid or active connection between the VM and an associated cell is established, however, associated registration information is retained in the associated cell/network. In the idle state, the VM may be allowed to utilize limited radio resources available in the single radio resource unit 112c to monitor paging events and to perform normal idle mode activities such as cell selection/reselection. In a suspended state, a VM may be totally suspended from using radio resources available in the single radio resource unit 112c. Before entering the suspended state, the VM may need to suspend or abort procedures such as, for example, data transfer, operating band change and/or manual public land mobile network (PLMN) search, which are currently being executed on the VM.
In an exemplary embodiment of the invention, the VMA 112b may be operable to collect performance metrics from a plurality of associated VMs. The VMA 112b may select a VM based on the collected performance metrics in order to perform a requested service. Depending on system configuration, the collected performance metrics may comprise, for example, user service request type, network availability, serving cell/network condition, quality of service (QoS), signal strength and/or navigation information associated with the multi-SIM multi-standby communication device 112. For a given time instant, different VMs in the multi-SIM multi-standby communication device 112 may camp on different cells or networks. In instances where the user of the multi-SIM multi-standby communication device 112 makes an emergency call, a VM associated with the best or most optimal quality serving cell or network may be selected to perform the emergency call. A serving cell or network for a service is the cell or network that is utilized to perform the service.

In an exemplary embodiment of the invention, the VMA 112b may be operable to switch a serving VM for a requested service based on the collected performance metrics. A VM that is utilized to perform a specific service is referred to as a serving VM for the specific service. For example, in instances where a serving VM for a file download service is experiencing a high block error rate (BLER), the VMA 112b may switch to another VM with a lower BLER to continue the file download service. In other words, the VMA 112b may utilize the VM with a lower BLER as a new serving VM to perform the file download service.

In various exemplary embodiments of the invention, the VMA 112b may be operable to dynamically configure VM capabilities based on the collected performance metrics. VM capabilities may comprise supported services and/or technologies such as 2 G, 3 G and 2 G/3 G utilized for multi-SIM multi-standby operation. For example, the VMA 112b may configure or set a VM to start with a 2 G only mode to support multi-SIM multi-standby operation at power up. In some instances, high data rate services may be requested during multi-SIM multi-standby operation. In this regard, the VMA 112b may configure the VM to operate in a 2 G/3 G dual mode to support the requested high data rate services. The VM may be configured to return to the 2 G only mode if the requested high data rate services are complete and/or no 3 G activities occur within a certain time period. In addition, one or more VMs may be dynamically turned on or off based on the collected performance metrics such as navigation information and/or signal strength. For example, the multi-SIM multi-standby communication device 112 may be configured to automatically turn off a VM for a work phone and turn on a VM for a personal phone whenever the user of multi-SIM multi-standby communication device 112 is near the home. The multi-SIM multi-standby communication device 112 may be configured to turn on or off a VM when signal strength of an associated network is above or below a threshold value.

The UMTS network 130 may comprise suitable devices, circuitry, interfaces and/or code that are operable to provide data and/or voice services to various UMTS capable communication devices such as the multi-SIM multi-standby communication device 112 using UMTS technology. In this regard, the UMTS network 130 may be operable to authenticate users such as the multi-SIM multi-standby communication devices 112-116 for UMTS access utilizing SIM cards. A SIM card for UMTS is also known as universal subscribe identity module (USIM). Only authorized users may access the UMTS network 130. The UMTS network 130 may be operable to check the validity of USIM identification information on one or more USIM cards coupled to, for example, the multi-SIM multi-standby communication device 112. The UMTS network 130 may determine whether the multi-standby communication device 112 is allowed to access the UMTS network 130 for various network services such as, for example, authentication, accounting and/or billing services.

The LTE network 140 may comprise suitable devices, circuitry, interfaces and/or code that are operable to provide data and/or voice services to various LTE capable communication devices such as the multi-SIM multi-standby communication device 112 using LTE technology. In this regard, the LTE network 140 may be operable to authenticate users such as the multi-SIM multi-standby communication devices 112-116 for LTE access utilizing SIM cards. A SIM card for LTE is also known as Universal Integrated Circuit Card (UIICC). Only authorized users may access the LTE network 140. The LTE network 140 may be operable to check the validity of UIICC identification information on one or more UIICCs coupled to, for example, the multi-SIM multi-standby communication device 112. The LTE network 140 may determine whether the multi-SIM multi-standby communication device 112 is allowed to access the LTE network 140 for various network services such as, for example, authentication, accounting and/or billing services.

The GSM network 150 may comprise suitable devices, circuitry, interfaces and/or code that are operable to provide data and/or voice services to various GSM capable communication devices such as the multi-SIM multi-standby communication device 112 using GSM technology. In this regard, the GSM network 150 may be operable to authenticate users such as the multi-SIM multi-standby communication devices 112-116 for GSM access utilizing SIM cards. Only authorized users may access the GSM network 150. The GSM network 150 may be operable to check the validity of SIM identification information on one or more SIM cards coupled to, for example, the multi-SIM multi-standby communication device 112. The GSM network 150 may determine whether the multi-SIM multi-standby communication device 112 is allowed to access the GSM network 150 for various network services such as, for example, authentication, accounting and/or billing services.

Although dynamically selecting and configuring one or more modems based on corresponding performance metrics to perform a requested service is illustrated in FIG. 1 for a VMA deployed on a single radio resource unit to handle multi-standby operations in a multi-SIM multi-standby communication device, the invention may not be so limited. Accordingly, dynamically selecting and configuring one or more modems based on corresponding performance metrics to perform a requested service may also be applied to various non-VMAs handling multi-standby operations in a multi-SIM multi-standby communication device without departing from the spirit and scope of various embodiments of the invention.

In an exemplary operation, a multi-SIM multi-standby communication device such as the multi-SIM multi-standby communication device 112 may be connected or coupled with multiple SIM cards such as the SIM cards 112a through one or more SIM card sockets or connections. SIM identification information on the multiple SIM cards may be utilized on one SIM card at a time and/or on multiple SIM cards.
cards at the same time depending on implementation. SIM identification information on each of the multiple SIM cards 112a may be communicated to the multi-SIM multi-standby communication device 112 through the one or more SIM card sockets. The multi-SIM multi-standby communication device 112 may operate in a single-standby mode or a multi-standby mode depending on device configuration and/or user preferences. A user of the multi-SIM multi-standby communication device 112 in a multi-standby mode may be allowed to utilize SIM identification information associated with each of the multiple SIM cards 112a to receive corresponding services at the same time. In this regard, the multi-SIM multi-standby communication device 112 may be operable to deploy the VMA 112b over the single radio resource unit 112c to support a multi-standby mode. The VMA 112b may be operable to receive, through a VMI, services associated with the multiple SIM cards 112a at the same time. Each of the VMs in the VMA 112b is assigned to serve one of the multiple SIM cards 112a.

[0035] In some instances, different VMs in the multi-SIM multi-standby communication device 112 may simultaneously camp on different cells or networks. In this regard, the multi-SIM multi-standby communication device 112 may track or collect performance metrics associated with the different VMs. A VM may be selected based on the collected performance metrics to perform a requested service. For example, a VM with the lowest measured BLER or highest signal level may be selected to perform a service such as file transfer protocol (FTP) or download service. In addition, a serving VM for the requested service may be dynamically switched among the different VMs based on the collected performance metrics such as QoS. For example, in instances where a voice call is performed utilizing a VM (current serving VM) associated with a higher time delay, the VMA 112b may switch to another VM (new serving VM) associated with a lower time delay to continue the voice call. Furthermore, VM capabilities may be dynamically configured based on the collected performance metrics. For example, certain functionalities such as 2 G or 3 G functionalities of a VM may be enabled or disabled based on a requested service type such as voice, video and multimedia, and/or navigation information associated with the multi-SIM multi-standby communication device 112. In some instances, a particular VM is selected and utilized to perform a requested service such as a streaming video service. The VMA 112b may turn off one or more other VMs to avoid radio resource contention and/or to reduce interferences so as to ensure the QoS of the streaming video service.

[0036] FIG. 2 is a block diagram illustrating an exemplary multi-SIM multi-standby communication device that is operable to dynamically select and configure virtual modems (VMs) based on performance metrics, in accordance with an embodiment of the invention. Referring to FIG. 2, there is shown a multi-SIM multi-standby communication device 200. The multi-SIM multi-standby communication device 200 comprises a wireless radio unit 202, a user interface unit 204, a processor unit 206, a SIM card controller 208 comprising SIM card sockets 208a-208c, a plurality of SIM cards, of which SIM cards 212-222 are illustrated, and a memory 220. The SIM cards 212-222 are coupled to the multi-SIM multi-standby communication device through the SIM card sockets 208a-208c. The memory 220 comprises a SIM database 220a. The wireless radio unit 202 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to communicate radio frequency signals with various communication networks such as, for example, the LTE network 140 and the GSM network 150. SIM identification information that is retrieved from one or more of the SIM cards 222-228 may be communicated via the wireless radio unit 202 to identify the multi-SIM multi-standby communication device 200 to network for desired network services such as accounting/billing services.

[0038] The user interface unit 204 may comprise suitable logic, circuitry, interfaces and/or code that may enable a user to interact with the multi-SIM multi-standby communication device 200. For example, the user interface unit 204 may be operable to present the user with information on SIM cards available to the multi-SIM multi-standby communication device 200. The user interface unit 204 may allow the user to enter a preferred SIM card selection and/or a desired application selection.

[0039] The processor unit 206 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to manage and/or control operations of device components such as, for example, the wireless radio unit 202, the user interface unit 204, the SIM database 220a, and/or the SIM card controller 208. For example, the processor unit 206 may be operable to coordinate and/or control operations of the SIM card controller 208 in response to a SIM card selection from the user interface unit 204. The processor unit 206 may also be operable to run a specific application via the application processor based on an application selection from the user interface unit 204.

[0040] The processor unit 206 may be operable to select one or more SIM cards based on user preferences and/or device configuration. The processor unit 206 may communicate the SIM card selection information to the SIM card controller 208 so that the selected one or more SIM cards may be connected to the SIM card sockets 208a-208c, which are directly coupled with the processor unit 206. The selected SIM cards may be actively connected to the SIM card controller 208 to enable downloading of corresponding SIM identification information into the SIM database 220a of the multi-SIM multi-standby communication device 200. Notwithstanding, in accordance with various embodiments of the invention, after SIM identification information is downloaded from each of the selected SIM cards such as the SIM cards 212-222 into the SIM database 220a of the multi-SIM multi-standby communication device 200, the SIM identification information corresponding to one or more of the plurality of SIM cards may be in an active state or in a standby state in the SIM database 220a. More specifically, at a given time instant, SIM identification information actually being utilized or applied to access corresponding services by the multi-SIM multi-standby communication device 200 is in an active state, otherwise, in a standby state.

[0041] In instances where the multi-SIM multi-standby communication device 200 is configured to operate in a single-standby mode, the processor unit 206 may communicate with the SIM database 220a to activate the stored SIM identification information related to one SIM card at a time. In other words, the multi-SIM multi-standby communication device 200, in a single-standby mode, may be operable to utilize SIM identification information activated for a single SIM card at a time. In instances where the multi-SIM multi-standby communication device 200 is configured to operate...
in a multi-standby mode, the processor unit 206 may be operable to communicate with the SIM database 220a to activate the stored SIM identification information corresponding to multiple SIM cards such as the SIM cards 212-222 at the same time. Specifically, the multi-SIM multi-standby communication device 200, in a multi-standby mode, may be operable to utilize SIM identification information activated for multiple SIM cards at the same time. In this regard, the processor unit 206 may be operable to allow a user of the multi-SIM multi-standby communication device 200 to utilize SIM identification information associated with each of the SIM cards 212-222 to receive corresponding services at the same time. For example, the user may therefore be allowed to utilize multiple numbers, multiple different service plans and/or network carriers associated with each of the multiple SIM cards 212-222 at the same time on the multi-SIM multi-standby communication device 200. The processor unit 206 comprises a communication processor 206a and an application processor 206b.

The communication processor 206a may comprise suitable logic, circuitry, interfaces and/or code that may be operable to utilize a Virtual Modern Architecture (VMA) 206c over a single radio resource unit such as the single radio resource unit 112c associated with the wireless radio unit 202 to support a multi-standby mode. The VMA 206c is a multi-SIM multi-standby platform and comprises a virtual modern controller (VMC), a virtual Model Framework (VMF) and a plurality of VMs. Each VM in the VMA 206c is assigned or related to one of the multiple SIM cards 212-222. For a given time instant, a VM may operate in one of a plurality of VM states, namely, an active state, an idle state or a suspended state. To avoid radio resource conflicts, at most one of the VMs in the VMA 206c may be in an active state to transmit and/or receive traffic related to a corresponding SIM card. One or more VMs may be in an idle state at the same time depending on radio resources available in the single radio resource unit 112c for sharing. One or more VMs may be in a suspended state at the same time. Radio resources available in the single radio resource unit 112c may be shared among the VMs.

In various exemplary embodiments of the invention, the VMA 206c may be operable to select a VM based on performance metrics such as BLER and time delay for a requested service. The VMA 206c may utilize the selected VM as a serving VM to perform the requested service. In this regard, the VMA 206c may track or collect performance metrics associated with the serving VM. The VMA 206c may switch the serving VM for the requested service among associated VMs based on the collected performance metrics. For example, in some instances, an increasing interference level is identified on the serving VM for the requested service. The VMA 206c may switch to another VM (new serving VM) with lower interference level to perform the requested service. One or more VM functions and/or VMs may be turned on or off based on the collected performance metrics to save resources such as power and bandwidth. For example, a VM may be turned on or off if the signal strength of an associated network is above or below certain levels, respectively. The VMA 206c may communicate traffic handled by the serving VM with the application processor 206b to support desired applications.

The application processor 206b may comprise suitable logic, circuitry, interfaces and/or code that may be operable to run or execute various applications such as video and/or audio multimedia applications based on traffic received by the communication processor 206a. The application processor 206b may present applications to users through the user interface unit 204.

The SIM card controller 208 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to manage and/or control connections from multiple SIM cards such as the SIM cards 212-222 to the SIM card sockets 208a-208c, which are directly coupled with the processor unit 206. In this regard, the SIM card controller 208 may be operable to establish connections between the SIM cards 212-222 and the processor unit 206. The SIM card controller 208 may be configured to switch SIM card connection from one to another as needed without re-booting the multi-SIM multi-standby communication device 200.

A SIM card such as the SIM card 214 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to store subscriber personal identification information such as, for example, operator network, phone number, activated services, billing, and credit information. The SIM card 214 may also store the user's identity for gaining access to the network and receiving calls, and user's personal information such as phone directory and received SMS messages. The SIM card 214 may be implemented as a small printed circuit board. The SIM card 214 may be inserted in a mobile device such as the multi-SIM multi-standby communication device 200 in order for the multi-SIM multi-standby communication device 200 to properly access a corresponding network. The SIM card 214 may be connected to the multi-SIM multi-standby communication device 200 via the SIM card controller 208.

The memory 220 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to store information such as executable instructions and data that may be utilized by the processor unit 206 and/or other device components such as, for example, the SIM database 208a. The SIM database 208a may comprise suitable logic, circuitry, interfaces and/or code that may be operable to record and/or store SIM identification information retrieved from one or more SIM cards such as the SIM cards 212-222. The stored SIM identification information may be in an active state or in a standby state within the SIM database 220a. For a given time instant, only SIM identification information in an active state may be utilized or applied by the multi-SIM multi-standby communication device 200 to support desired network services such as accounting/billing services. Depending on device configuration, for a given time instant, SIM identification information in an active state may correspond to one or more SIM cards. The memory 220 may comprise RAM, ROM, low latency nonvolatile memory such as flash memory and/or other suitable electronic data storage.

In an exemplary operation, a multi-SIM multi-standby communication device such as the multi-SIM multi-standby communication device 200 may be connected or coupled to multiple SIM cards such as the SIM cards 212-222 through the SIM card controller 208. The processor unit 206 may be operable to retrieve SIM identification information from the SIM cards 212-222. The retrieved SIM identification information may be stored in the SIM database 220a. In instances where the multi-SIM multi-standby communication device 200 is configured to operate in a multi-standby mode, the communication processor 206a may communicate with the SIM database 220a to activate the stored SIM identification information corresponding to multiple SIM cards.
such as the SIM cards 212-222 at the same time. More specifically, the multi-SIM multi-standby communication device 200, in a multi-standby mode, may utilize SIM identification information activated for the SIM cards 212-222 at the same time. A user of the multi-SIM multi-standby communication device 200 may therefore be allowed to receive services related to the SIM cards 212-222 at the same time. The communication processor 206a may run the VMA 206c over the single radio resource unit 112c to handle traffic through the wireless radio unit 202.

[0049] Radio resources available in the single radio resource unit 112c may be shared among the VMs in the VMA 206c. The shared radio resources in the single radio resource unit 112c may allow the VMs in the multi-SIM multi-standby communication device 200 may camp on different cells or networks. The VMA 206c may monitor and collect performance metrics associated with the different VMs. Upon the receipt of a service request, the VMA 206c may be operable to select a VM from the different VMs based on the collected performance metrics such as service request type and/or QoS. The selected VM may be utilized, as a serving VM, to perform a requested service. The VMA 206c may track and collect performance metrics associated with the serving VM. The serving VM may be dynamically switched for the requested service based on the collected performance metrics such as time delay and/or signal strength. VM capabilities such as 2G or 3G service support may be configured based on the collected performance metrics such as associated navigation information to save power and/or bandwidth. Traffic associated with the requested service may be communicated with the application processor 206b. The application processor 206b may run or execute various applications such as video and/or audio multimedia applications according to the communicated traffic and present it to users via the user interface unit 204.

[0050] FIG. 3 is a block diagram illustrating an exemplary multi-instance virtual modem approach to concurrently handle multi-instance tasks on a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention. Referring to FIG. 3, there is shown virtual modem architecture 300 utilized on the multi-SIM multi-standby communication device 200, for example. The virtual modem architecture 300 comprises man-machine interface (MMI) module 310, a SIMIO module 320, a virtual modem framework (VMF) 330, a virtual modem controller (VMC) 360, and a single radio resource unit 370.

[0051] The MMI module 310 may comprise suitable logic, interfaces and/or code that may be operable to provide interaction between a user of the multi-SIM multi-standby communication device 200 and one or more applications that are executed on the multi-SIM multi-standby communication device 200.

[0052] The SIMIO module 320 may comprise suitable logic, interfaces and/or code that may be operable to manage access to SIM cards such as the SIM cards 212-222.

[0053] The VMF 330 may comprise suitable logic, interfaces and/or code that may be operable to provide an enhancement to the Real Time Operating System. The VMF 330 may be deployed or implemented on the communications processor 206a.

[0054] A VM such as the VM 340 refers to an instance of an air interface protocol stack and/or its interface to the user, namely, a Common Application Programming Interface (CAPI), together with a single set of radio resources such as radio resources available in the single radio resource unit 370. A VM such as the VM 340 may comprise suitable logic, interfaces and/or code that may be operable to handle instances, namely, CAPI tasks and/or air interface protocol stack instances, associated with one of the SIM cards 212-222. Different VMs such as the VM 340 and the VM 350 may be configured to handle instances corresponding to two different SIM cards. For example, the VM 340 may handle instances related to the SIM card 212, while the VM 350 may be assigned to handle instances related to the SIM card 214. The plurality of VMs such as VMs 340-350 may be configured to share the same set of radio resources, namely, available radio resources in the single radio resource unit 370. In this regard, multiple copies of global and static data may be maintained to be utilized by the VMs 340-350, respectively. A VM such as the VM 340 may operate independently from other VMs and may be in one of the plurality of VM states, namely, an active state, an idle state and a suspended state. The VM 340 may comprise a CAPI task unit 342, a VCC 344, an air interface protocol stack 346 together with the single radio resource unit 370. CAPI and/or stack operations within the VM 340 may be managed via the VCC 344.

[0055] The CAPI task unit 342 may comprise suitable logic, interfaces and/or code that may be operable to process MMI and/or user requests. The CAPI task unit 342 comprises CAPI tasks related to a specific SIM card such as the SIM card 212.

[0056] A VCC such as the VCC 344 may comprise suitable logic, interfaces and/or code that may be operable to perform admission control with the VMC 360 for the CAPI module 315 at the primitive levels. The VCC 344 is a dual-instance module for managing its own task or instance, and queuing messages. The VCC 344 may be operable to interact with the VMC 360 for radio resource requests associated with CAPI tasks in the CAPI task unit 342. The VCC 344 may communicate with the air interface protocol stack 346 to coordinate stack operations corresponding to the CAPI tasks in the CAPI task unit 342.

[0057] An air interface protocol stack such as the air interface protocol stack 346 may comprise suitable logic, interfaces and/or code that may be operable to provide air interface protocols to support various signaling operations. For example, in 3GPP standard, the stack 346 may comprise Non-Access-Stratum (NAS) protocols and Access-Stratum (AS) protocols to handle bearer level signaling and Radio Resource Control (RRC) signaling, respectively.

[0058] The VMC 360 may comprise suitable logic, interfaces and/or code that may be operable to coordinate requests for the usage of radio resources available in the single radio resource unit 370 among multiple associated VMs such as the VM 340 and the VM 350. In this regard, the VMC 360 may be operable to resolve contention for radio resources by transmitting the VM 340 and the VM 350 between the three VM states. For example, the VMC 360 may be operable to ensure that at most one of the VM 340 and the VM 350 is in the active state for a given time instant. In this regard, the VMC 360 may suspend, for example, the VM 350 from using or sharing radio resources available in the single radio resource unit 370 in order to allow an uninterrupted radio resource usage by the VM 340. The suspended VM 350 may be resumed whenever
radio resources in the single radio resource unit 370 become available for sharing by the VM 350 to continue idle mode activities on the VM 350.

[0059] The VMC 360 may be operable to coordinate the usage of the radio resources to support concurrent procedures initiated by the VM 340 and the VM 350. For example, the VM 340 and the VM 350 each may be granted by the VMC 360 a portion of radio resources available in the single radio resource unit 370 to concurrently monitor paging events and/or to concurrently perform idle mode procedures or activities such as, for example, cell selection/reselection by sharing the single radio resource unit 370. In this regard, the VMC 360 may be operable to perform access arbitration at the task level in order to control concurrent access to the shared radio resources from multiple VM tasks of the VM 340 and/or the VM 350. For example, for each of intended VM tasks, the VMC 360 may be operable to tabulate activities associated with an intended VM task and on-going activities associated with one or more of plurality of VMs for a conflict check.

[0060] In instances where one or more perceived or actual conflicts occur, the VMC 360 may be operable to perform access arbitration on the intended VM task based on VM task priority information, activity status of one or more of plurality of VMs and/or radio resources available in the single radio resource unit 370. The access for the intended VM task may be immediately accepted, accepted with a delay or rejected. In instances where the access for the intended VM task is delayed, the VMC 360 may be operable to determine what time instants the access for the intended VM task may be accepted or granted. A VM associated with the VM task may re-send an admission request to the VMC 360 for the same VM task at the determined one or more time instants. After the access for the VM task is accepted, the VMC 360 may be operable to assign radio resources to the VM task to proceed with associated activities such as receiving traffic related to a corresponding SIM card such as the SIM card 212.

[0061] The single radio resource unit 370 may comprise suitable logic, interfaces and/or code that may be operable to provide PHY and RF support.

[0062] In an exemplary operation, the MMI module 310 may interact between a user of the multi-SIM multi-standby communication device 200 and applications that are related to the SIM card 212 and the SIM card 214, for example, inserted into the SIM card controller 208. Tasks or instances related to the SIM card 212 and the SIM card 214 may be handled by the VM 340 and the VM 350, respectively. The VMC 360 may coordinate the usage of radio resources available in the single radio resource unit 370 for sharing by the VM 340 and the VM 350. In this regard, the VMC 360 may be operable to control the access to radio resources available in the single radio resource unit 370 by performing access arbitration at each VM task. More specifically, the VMC 360 may manage or control the concurrent accesses to the shared radio resources from multiple VM tasks of the VM 340 and/or the VM 350. For an intended VM task, the VMC 360 may be operable to compare activities associated with the intended VM task with on-going activities associated with one or more of the plurality of VMs for a conflict check. In instances where one or more conflicts occur, the VMC 360 may arbitrate the access for the intended VM task based on VM task priority information, activity status of other VMs and radio resources available in the single radio resource unit 370. The intended VM task may be immediately accepted, accepted with a delay or rejected. With a delayed access for the intended VM task, the VMC 360 may be operable to provide information on when the intended VM task should be accepted to a corresponding VM such as the VM 340. The VM 340 may repeat the admission request for the same VM task at corresponding time instants. After the access for the intended VM task is accepted, the VMC 360 may be operable to assign radio resources to the intended VM task to proceed with associated activities such as receiving traffic related to a corresponding SIM card such as the SIM card 212.

[0063] FIG. 4 is a flow chart illustrating exemplary steps that may be utilized by a virtual modem controller to select a virtual modem (VM) based on performance metrics to perform a requested service in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention. Referring to FIG. 4, the exemplary steps may start with step 402. In step 402, multiple SIM cards such as the SIM cards 212-222 may be inserted into the SIM card controller 208 to support multi-SIM multi-standby operation. In step 404, the VMC 360 may collect performance metrics for each of the VMs associated with the inserted SIM cards 212-222. In step 406, it may be determined whether a service request is received. In instances where a service request is received, then in step 408, the VMC 360 may be operable to select a VM based on the collected performance metrics. In this regard, the selected VM may correspond to the best or most optimal performance metrics. In step 410, the selected VM may be utilized to perform the requested service.

[0064] In step 406, in instances where a service request is not received, then control passes to step 404.

[0065] FIG. 5 is a flow chart illustrating exemplary steps that may be utilized by a virtual modem controller to switch a serving virtual modem (VM) based on performance metrics to perform a requested service in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention. Referring to FIG. 5, the exemplary steps may start with step 502. In step 502, multiple SIM cards such as the SIM cards 212-222 may be inserted into the SIM card controller 208 to support multi-SIM multi-standby operation. In step 504, the VMC 360 may select one of VMs associated with the inserted SIM cards 212-222, as a serving VM, for the requested service. In step 506, the selected serving VM may be utilized to perform the requested service. In step 508, the VMC 360 may track and collect performance metrics associated with the serving VM and other VMs. In step 510, it may be determined whether there are one or more VMs associated with better performance metrics. In instances where there are one or more VMs associated with better performance metrics, then in step 512, the VMC 360 may be operable to select a VM corresponding to the best or most optimal performance metrics as a new serving VM to serve the requested service. The exemplary steps may return to step 506.

[0066] In step 510, in instances where there are no other VMs associated with better performance metrics, then control passes to step 506.

[0067] FIG. 6 is a flow chart illustrating exemplary steps that may be utilized by a virtual modem controller to configure virtual modem (VM) capabilities based on performance metrics in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention. Referring to FIG. 6, the exemplary steps may start with step 602. In step 602, multiple SIM cards such as the SIM cards 212-222 may be inserted into the SIM card controller 208 to support multi-SIM multi-standby operation. In step 604, the VMC 360 may track and collect performance metrics for VMs
associated with the inserted SIM cards 212-222. In step 606, the VMC 360 may configure VM capabilities of the VMs based on the collected performance metrics.

FIG. 7 is a flow chart illustrating exemplary steps that may be utilized by a virtual modem controller to turn on/off a virtual modem (VM) based on performance metrics in a multi-SIM multi-standby communication device, in accordance with an embodiment of the invention. Referring to FIG. 7, the exemplary steps may start with step 702. In step 702, multiple SIM cards such as the SIM cards 212-222 may be inserted into the SIM card controller 208 to support multi-SIM multi-standby operation. In step 704, the VMC 360 may track and collect performance metrics for VMs associated with the inserted SIM cards 212-222. In step 706, the VMC 360 may turn on or off one or more of the VMs and/or certain VM functionalities based on the collected performance metrics.

In various exemplary aspects of the method and system for dynamically selecting and configuring virtual modems (VMs) based on performance metrics in a multi-SIM multi-standby communication device, a multi-SIM and multi-standby communication device such as the multi-SIM multi-standby communication device 200 comprises a single radio resource unit such as the single radio resource unit 370. Each of the VMs is uniquely associated with a single one of a plurality of SIM cards such as the SIM cards 212-222 that are coupled to the multi-SIM multi-standby communication device 200 through the SIM card controller 208. Operations of the VMs in the VMA 330 may be managed or coordinated by the VMC 360. The VMC 360 may also be operable to control the access, for each VM, to radio resources available in the single radio resource unit 370.

The VMC 360 may track and collect performance metrics associated with each of the plurality of VMs. The VMC 360 may select a VM such as the VM 340 based on the collected performance metrics to perform a requested service. The collected performance metrics may comprise, for example, a requested service type, network availability, quality of service (QoS), signal strength and/or navigation information. The VMC 360 may switch a serving VM among the plurality of VMs based on the collected performance metrics to perform the requested service. VM capabilities may be dynamically configured based on the collected performance metrics. The VMC 360 may be operable to enable or disable at least a portion of VM capabilities based on the collected performance metrics. For example, the VMC 360 may enable or disable VM capabilities such as short messaging service (SMS) and/or cell broadcasting service support based on navigation information such as, for example, location, velocity and/or time, associated with the multi-SIM multi-standby communication device 200. In another example, the VMC 360 may enable or disable VM capabilities such as 3 G support based on a requested service type. In addition, the VMC 360 may be operable to turn on or off one or more VMs based on the collected performance metrics such as a requested service type. The VMC 360 may turn on or off certain VMs based on navigation information such as location associated with the multi-SIM multi-standby communication device 200. For example, assume that the VM 340 may be utilized to serve a home phone and the VM 350 may be utilized to serve a work phone. The VMC 360 may turn on the VM 340 and turn off the VM 350 whenever the user is near home. The VMC 360 may set the multi-SIM multi-standby communication device 200 to turn off the VM 340 and turn on the VM 350 whenever the user is near home.

Other embodiments of the invention may provide a non-transitory computer readable medium and/or storage medium, and/or a non-transitory machine readable medium and/or storage medium, having stored thereon, a machine code and/or a computer program having at least one code section executable by a machine and/or a computer, thereby causing the machine and/or computer to perform the steps as described herein for dynamically selecting and configuring virtual modems (VMs) based on performance metrics in a multi-SIM multi-standby communication device.

Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system, or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

The present invention may also be embodied in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for communication, the method comprising:
   - in a multiple-subscriber identity module (multi-SIM) multi-standby communication device comprising a single radio resource unit that is shared by a plurality of virtual modems;
     - collecting performance metrics associated with each of said plurality of virtual modems;
     - selecting a virtual modem from said plurality of virtual modems based on said collected performance metrics to perform a requested service.

2. The method according to claim 1, wherein said collected performance metrics comprises requested service type, network availability, quality of service (QoS), signal strength and/or navigation information.
3. The method according to claim 2, comprising switching to another one of said plurality of virtual modems based on said collected performance metrics to perform said requested service.

4. The method according to claim 2, comprising configuring corresponding capabilities of said plurality of virtual modems based on said collected performance metrics.

5. The method according to claim 4, comprising enabling or disabling at least a portion of said corresponding capabilities of said plurality of virtual modems based on said collected performance metrics.

6. The method according to claim 5, comprising enabling or disabling said at least portion of said corresponding capabilities of said plurality of virtual modems based on navigation information associated with said multi-SIM multi-standby communication device.

7. The method according to claim 5, comprising enabling or disabling said at least portion of said corresponding capabilities of said plurality of virtual modems based on navigation information associated with said multi-SIM multi-standby communication device.

8. The method according to claim 6, comprising turning on or off one or more of said plurality of virtual modems based on said collected performance metrics.

9. The method according to claim 8, comprising turning on or off one or more of said plurality of virtual modems based on said collected performance metrics.

10. The method according to claim 9, comprising turning on or off said one or more of said plurality of virtual modems based on said collected performance metrics.

11. A system for communication, the system comprising:

   a. One or more processors and/or circuits for use in a multiple-subscriber identity module (multi-SIM) multi-standby communication device comprising a single radio resource unit that is shared by a plurality of virtual modems, said one or more processors and/or circuits being operable to:

   b. Collect performance metrics associated with each of said plurality of virtual modems; and

   c. Select a virtual modem from said plurality of virtual modems based on said collected performance metrics to perform a requested service.

12. The system according to claim 11, wherein said collected performance metrics comprises requested service type, network availability, quality of service (QoS), signal strength and/or navigation information.

13. The system according to claim 12, wherein said one or more processors and/or circuits being operable to switch to another one of said plurality of virtual modems based on said collected performance metrics to perform said requested service.

14. The system according to claim 12, wherein said one or more processors and/or circuits being operable to configure corresponding capabilities of said plurality of virtual modems based on said collected performance metrics.

15. The system according to claim 14, wherein said one or more processors and/or circuits being operable to enable or disable said at least portion of said corresponding capabilities of said plurality of virtual modems based on said collected performance metrics.

16. The system according to claim 15, wherein said one or more processors and/or circuits being operable to enable or disable said at least portion of said corresponding capabilities of said plurality of virtual modems based on navigation information associated with said multi-SIM multi-standby communication device.

17. The system according to claim 15, wherein said one or more processors and/or circuits being operable to enable or disable said at least portion of said corresponding capabilities of said plurality of virtual modems based on service type for said requested service.

18. The system according to claim 14, wherein said one or more processors and/or circuits being operable to turn on or off said one or more of said plurality of virtual modems based on said collected performance metrics.

19. The system according to claim 18, wherein said one or more processors and/or circuits being operable to turn on or off said one or more of said plurality of virtual modems based on navigation information associated with said multi-SIM multi-standby communication device.

20. The system according to claim 18, wherein said one or more processors and/or circuits being operable to turn on or off said one or more of said plurality of virtual modems based on service type for said requested service.