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EFFICIENT CELLULAR RADIO ACCESS MANAGEMENT FOR MOBILE COMPUTING DEVICES

Meng Wang

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ABSTRACT

Next generation cellular radios are being developed that facilitate higher (compared to legacy cellular radios) bandwidth, lower latency, etc. While mobile computing devices may include the next generation cellular radios, deployment of next generation cellular base stations that provide full next generation support is sparse. As such next generation cellular radios have only recently been introduced, the next generation cellular radios have not been subjected to extensive power optimization, resulting in significant power consumption (particularly when not connected to the sparsely deployed next generation cellular base stations). Techniques described in this disclosure enable efficient cellular radio access management for mobile computing devices in which the mobile computing devices actively enable and disable the next generation cellular radio based on a proximity to the next generation cellular base stations (or, in other words, geofencing).

DESCRIPTION

Techniques are described that enable a computing device 10 to manage cellular radio access more efficiently (in terms of power consumption) by enabling and disabling cellular radio access based on a proximity to the next generation cellular base station. Computing device 10 may represent a mobile computing device, such as a tablet computer, a mobile phone (including so-called “smartphones”), a smart watch, smart glasses, a smart speaker, a portable gaming system, a vehicle head unit, a standalone virtual assistance device, or any other device capable of communicating with a cellular base station via a cellular radio.

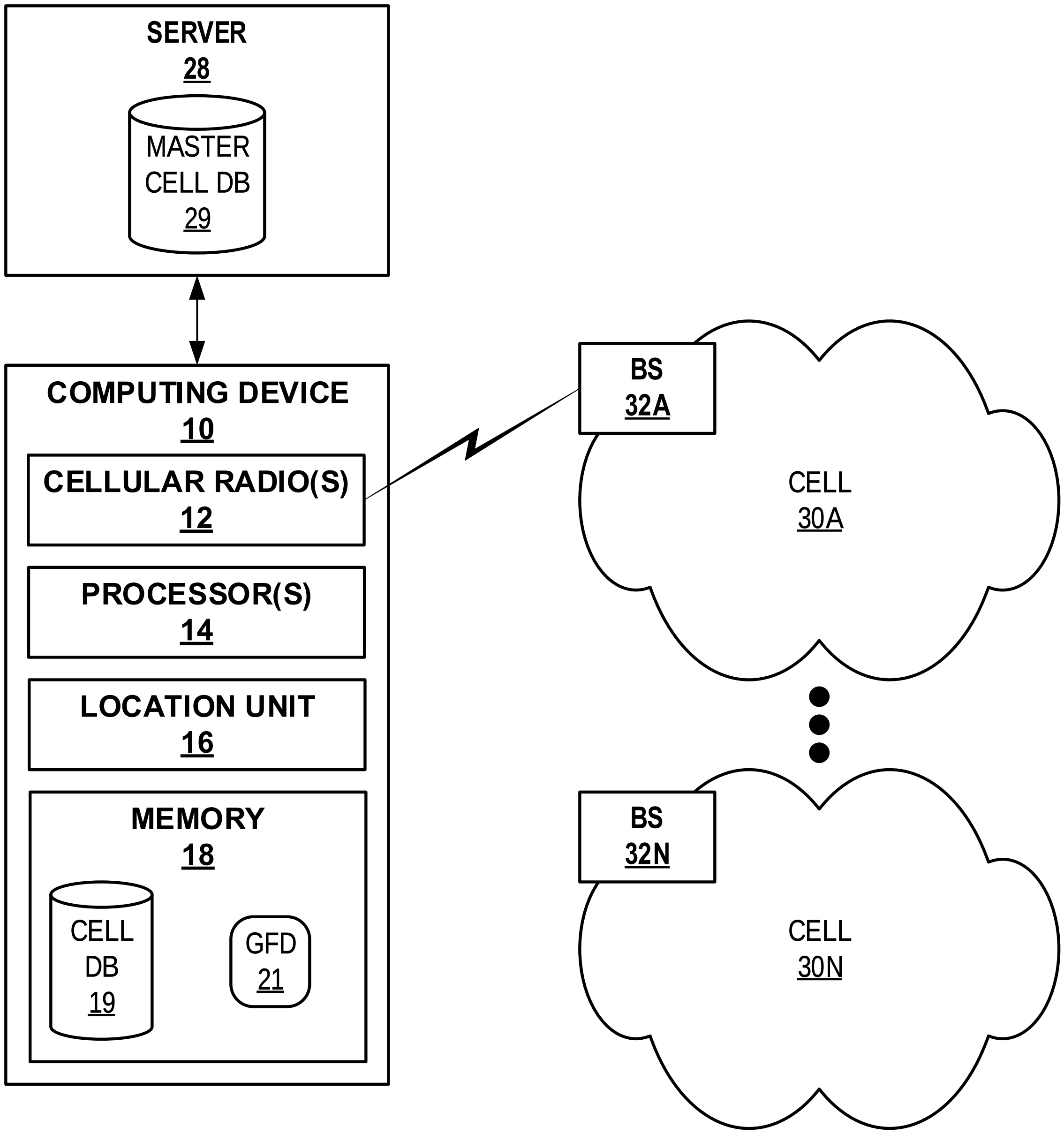

FIG. 1

As shown in the example of FIG. 1, computing device 10 may include one or more cellular radio(s) 12, one or more processor(s) 14, a location unit 16, and a memory 18. Cellular radio(s) 12 may include one or more cellular radios capable of communicating with base stations (BSs) 32A-32N ("BSs 32") according to various cellular communication standards. Cellular communication standards may include cellular communication standards set forth by the 3rd generation partnership project (3GPP), such as global system for mobile communications (GSM) (including a general packet radio service – GPRS, and enhanced data rates for GSM evolution – EDGE), universal mobile telecommunication system (UMTS) (including high speed packet access – HSPA), long term evolution (LTE), LTE advanced, LTE advanced pro, 5G (including 5G new radio – NR).

Processors 14 may represent any type of hardware configured to perform various operations described herein to facilitate efficient management of cellular radios 12. Examples of processor 14 include, but are not limited to, digital signal processors (DSPs), general purpose microprocessors (where multiple processor may be housed in the same package - whereupon each processor may represent a different processing core - or in separate packages), application specific integrated circuits (ASICs), field programmable logic arrays (FPGAs), or other equivalent integrated or discrete logic circuitry.

Location unit 16 may represent a unit configured to determine a current location of computing device 10. In some examples, location unit 16 may represent a global positioning system (GPS) unit that identifies the current location of computing device 10 in terms of GPS coordinates. Location unit 16 may, however, represent other types of units configured to determine the current location of computing device 10, including other types of global navigation satellite systems (GNSS) units, such as a global navigation satellite system (GLONASS) unit, BeiDou Navigation Satellite System (BDS) unit, a Galileo unit, and the like.

Memory 18 may represent memory that facilitates quick access to date by processors 14. Memory 18 may form one part of a larger storage architecture (which is not shown for ease of illustration), in which data is not stored to memory 18 indefinitely but is cached at memory 18, where data is moved in and out of memory 18 from and to a non-volatile storage component.

Examples of volatile memories include random access memories (RAM), dynamic random access memories (DRAM), static random access memories (SRAM), and other forms of volatile memories known in the art.

The storage components may be configured for long-term storage of information as non-volatile memory space and retain information after power on/off cycles. Examples of non-volatile memories include magnetic hard discs, flash memories, or forms of electrically programmable memories (EPROM) or electrically erasable and programmable (EEPROM) memories.

As further shown in the example of FIG. 1, computing device 10 may communicate wirelessly with BSs 32, each of which support a cell 30A-30N (respectively). Cells 30A-30N ("cells 30") may each represent a distinct cellular network cell, which may overlap one another in terms of geographical coverage or be entirely separate. Cells 30 may conform to one or more of the foregoing cellular network standards providing data service (such as Internet data service) in accordance with the foregoing cellular network standards. Although not shown in the example of FIG. 1, cells 30 may provide a way by which to access a public network (such as the Internet). Cells 30 may offer a form of wireless network services by which computing device 10 may interact with the public networks.

BSs 32 represent computing devices configured to present a wireless interface to each respective cell 30 in accordance with the foregoing cellular network standards. BSs 32 may be installed on towers or other typically high locations (e.g., tops of buildings), emitting wireless signals by which computing device 10 may identify each BSs 32 and the corresponding capabilities in terms of which of the cellular network standards are supported. Computing device 10 may interface with BSs 32 within a geographical distance denoted by cell 30.

Next generation cellular radios are being developed that facilitate higher (compared to legacy cellular radios) bandwidth, lower latency, etc. While computing device 10 may include the next generation cellular radios as one of cellular radios 12, deployment of next generation cellular base stations (e.g., one or more of BSs 32) that provide full next generation support is sparse (in terms of geographical locations). As such next generation cellular radios have only recently been introduced, the next generation cellular radios have not been subjected to extensive power optimization, resulting in significant power consumption (particularly when not connected to the sparsely deployed next generation cellular base stations). That is, enabling a next generation cellular radio (such as a 5G NR cellular radio) when no 5G NR BS is present may consume significant amounts of power as the 5G NR cellular radio may periodically (and potentially with high frequency) scan for a compatible 5G NR BS when none may be within a given proximity of computing device 10, thereby potentially needlessly consuming power and reducing a battery life of computing device 10.

Processors 14 may be configured to implement one or more aspects of the techniques set forth in this disclosure to manage cellular radio access more efficiently (in terms of power consumption) by enabling and disabling 5G NR radios of cellular radios 12 based on a proximity to the next generation cellular base stations of BSs 32. As shown in the example of FIG. 2 below, processor 14 of computing device 10 may initialize a geofence for a geofence distance (“GFD 21”) from the current location (as determined by location unit 16). Next, processor 14 may interface with a server, such as server 28 as also shown above in the example of FIG. 1, to request 5G NR BSs of BS 32 within GFD 21.

Processors 14 may communicate with server 28 in a number of different ways. Processor 14 may communicate with server 28 using one or more of cellular radios 12 (such as a 4G cellular radio), via a wireless communication session established via WiFi™ or other wireless communication standard, or via any other type of wired or wireless connection. Server 28 may be operated by a cellular service provider and located in a backend network reachable via a public network, such as the Internet.

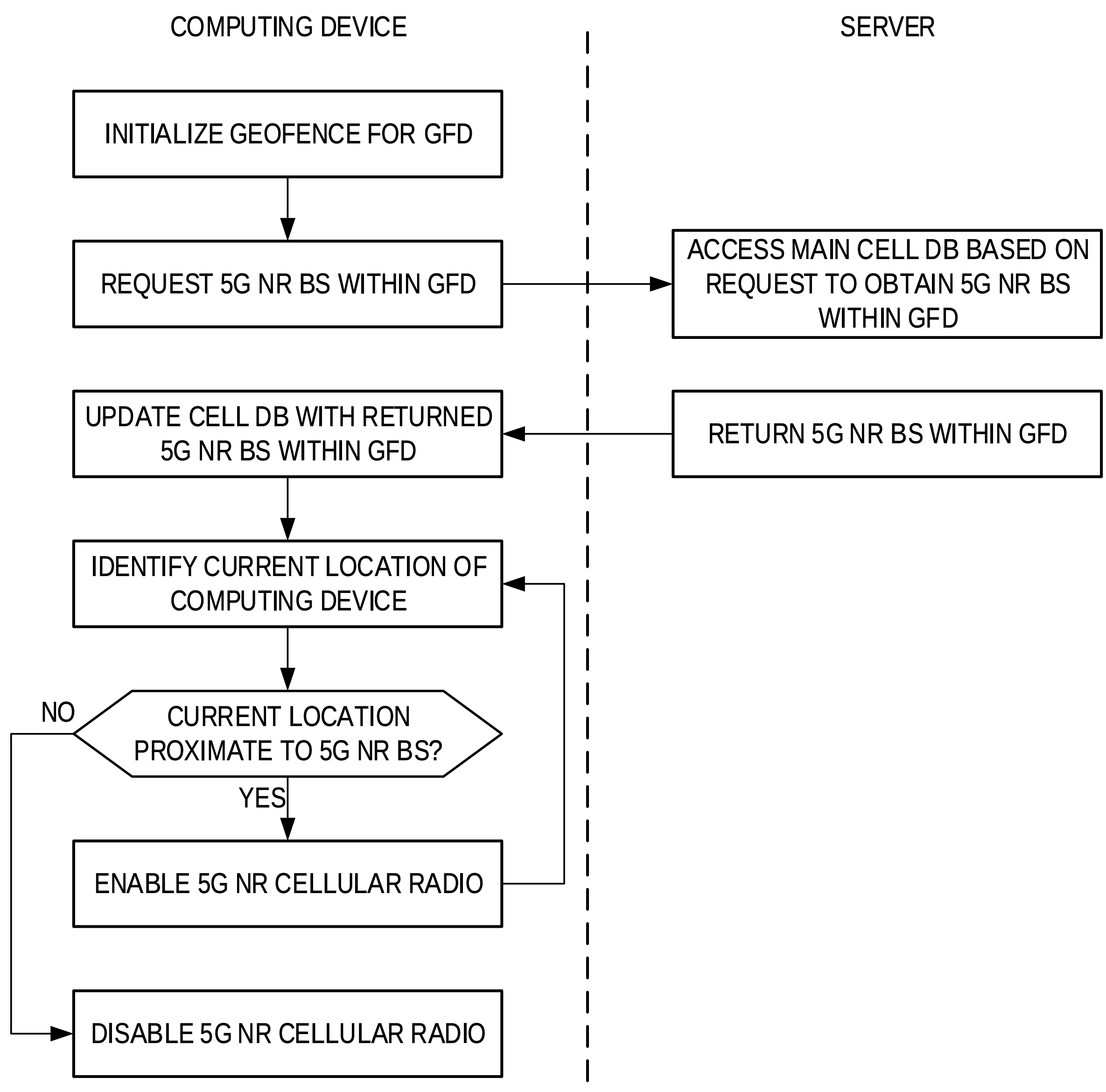

FIG. 2

Server 28 may represent any type of network device capable of hosting a database (DB 29 by which to store information specifying 5G NR cells and associated metadata (e.g., location, type, services offered, etc.). Server 28 may access main cell DB 29 based on the request to obtain 5G NR BS within GFD 21 from the current location of computing device 10. Server 28 may return, to computing device 10, 5G NR BS within GFD 21 of the current location of computing device 10.

Processor 14 may update cell DB 19 with the returned 5G NR BSs within GFD 21 of the current location of computing device 10, thereby syncing cell DB 19 with a location specific subset of master cell DB 29. Processor 14 may interface with location unit 16 to identify the current location of computing device 10 (which may have changed due to movement of computing device 10 while syncing cell DB 19).

In some examples, processor 14 may generate the request such that the request is encrypted (e.g., hypertext transfer protocol secure - HTTPS), while server 28 may store the cell information in encrypted form. Similarly, server 28 may return the results in encrypted form (e.g., using HTTPS), while processor 14 may store the returned results to cell DB 19 as encrypted results. Encryption may be provided to ensure sensitive network service provider information regarding the deployment of 5G NR BSs is not compromised. In addition, the cell information may be provided by the service providers or by 5G capable computing devices (which may report 5G cells when a new 5G cell is discovered).

Processor 14 may query cell DB 19 based on the current location to determine whether the current location is proximate to one of the 5G NR BS returned by server 28. When the current location is not proximate to one of the 5G NR BS returned by server 28, processor 14 may disable (or potentially maintain an inactive state of) the 5G NR cellular radio of cellular radios 12. When the current location is proximate to one of the 5G NR BS returned by server 28, processor 14 may enable (or potentially maintain an active state of) the 5G NR cellular radio of cellular radios 12. By selectively enabling or disabling the 5G NR cellular radio only when proximate to a 5G NR BS, processor 14 may avoid needless consumption of power.

In the example of FIG. 2, processor 14 operates to avoid power consumption when computing device 10 has only moved a short range (e.g., less than GFD 21). Processor 14 may transition to a different mode when certain circumstances occur (e.g., detecting rapid movement via a vehicle). The example illustrated in FIG. 3 shows how processor 14 may operate responsive to detecting that computing device 10 is moving potentially longer distances relative to the example discussed above with respect to FIG. 2.

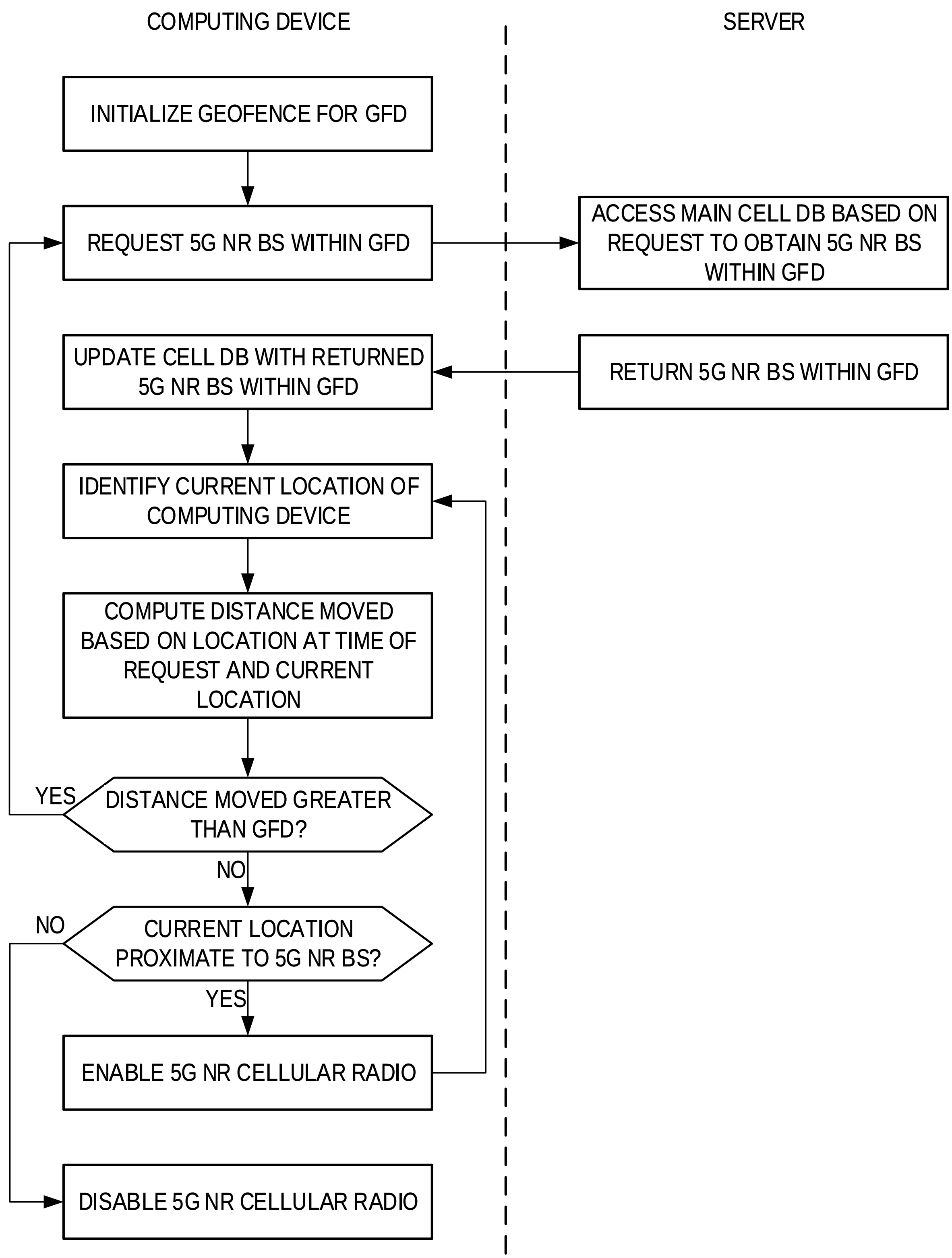
COMPUTING DEVICE
SERVER
INITIALIZE GEOFENCE FOR GFD
REQUEST 5G NR BS WITHIN GFD
ACCESS MAIN CELL DB BASED ON REQUEST TO OBTAIN 5G NR BS WITHIN GFD
UPDATE CELL DB WITH RETURNED 5G NR BS WITHIN GFD
RETURN 5G NR BS WITHIN GFD
IDENTIFY CURRENT LOCATION OF COMPUTING DEVICE
COMPUTE DISTANCE MOVED BASED ON LOCATION AT TIME OF REQUEST AND CURRENT LOCATION
YES
DISTANCE MOVED GREATER THAN GFD?
NO
NO
CURRENT LOCATION PROXIMATE TO 5G NR BS?
YES
ENABLE 5G NR CELLULAR RADIO
DISABLE 5G NR CELLULAR RADIO

FIG. 3

Processor 14 may operate similarly in the example of FIG. 3 to that shown above with respect to FIG. 2, except that processor 14 may inject a determination of a distance moved after identifying the current location of computing device 10. That is, processor 14 may compute the distance moved based on the location at time of the request for the 5G NR BS from server 28 and the current location.

When the distance moved is greater than GFD 21, processor 14 may request 5G NR BS within GFD 21 of the now current location, which may result in resynching cell DB 19 on computing device 10 with those 5G NR BS within GFD 21 of the current location of computing device 10. When the distance moved is not greater than GFD 21, processor 14 may continue using existing cell DB 19 (without performing the resync) in the manner described below with respect to FIG. 2. However, unlike in the example of FIG. 2, processor 14 may continue to determine the current location, and perform the distance moved check. Once processor 14 determines that the foregoing certain conditions no longer exist (e.g., stop rapid movement, such as traveling in the vehicle), processor 14 may revert to the operation shown in FIG. 2.

The above process is described largely as being automated with processor 14 being configured to automatically enable and disable next generation cellular radios 12. However, processor 14 may prompt the user to turn on and off the cellular radios 12 manually. Furthermore, processor 14 may also attempt to reduce next generation cellular radio activation by only activating the next generation cellular radio when bandwidth demand or low-latency demand is requested (e.g., by applications).

It is noted that the techniques of this disclosure may be combined with any other suitable technique or combination of techniques. As an example, the techniques of this disclosure may be combined with the techniques described in WO 2017/196510, entitled "METHOD AND/OR SYSTEM FOR POSITIONING OF A MOBILE DEVICE."