April 2020

Selective Disabling of Antenna Modules Affected by Handgrip or Other Blockage

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SELECTIVE DISABLING OF ANTENNA MODULES AFFECTED BY HANDGRIP OR OTHER BLOCKAGE

Abstract

User equipment (UE) employing millimeter-wave (mmWave) radio frequency (RF) signaling uses one or more techniques to detect signaling blockages caused by handgrip, body blockage, or lack of line-of-sight with the wireless base station, identifies one or more antenna modules of an array of antenna modules of the UE affected by the blockage, and temporarily disables the one or more affected antenna modules until the blockage is no longer present. As the UE otherwise would consume considerable power attempting to overcome the blockage at the affected antenna module, either by transmitting at a higher power to overcome the attenuation caused by the blockage or to continue to ineffectively scan via the affected antenna module, this selective antenna module disablement process can reduce power consumption at the UE while facilitating a high-quality user experience.

Background

The Fifth Generation (5G) New Radio (NR) specification provides for optional utilization of radio access technologies (RATs) that wirelessly communicate in so-called “millimeter wave” or “mmWave” bands of frequencies (e.g., 24, 28, and 39 gigahertz (GHz) frequencies). Due in part to the higher frequencies, mmWave-based communications can provide higher speeds than legacy RATs, but often at the cost of increased power consumption. Moreover, because of their relatively short wavelengths, mmWave transmissions are particularly susceptible to blockage. In the case of UEs in the form of cellular phones and other wireless portable devices, this blockage often is at least partially a result of the user’s handgrip or the user’s body positioned between the device and the wireless base station. Such blockage can lead to unnecessary power consumption by the UE as it attempts to transmit at a higher power to overcome the blockage or continue to perform scans using portions of an antenna array affected by the blockage. While certain approaches have been developed to reduce the power consumed by mmWave-based communications, such as through ceasing beam scanning based on active/inactive state as taught in U.S. Patent Application Publication No. 20180269954A1 or in the beam-selection process through proximate obstacle detection as taught in U.S. Patent Application Publication No. 20190393944A1 (the entireties of which are incorporated by reference herein), these approaches are not attuned to the particular impacts of handgrip or body blockages on the operation of the antennae of the UE.

Description

As illustrated by FIG. 1 below, in a mmWave implementation, a wireless portable device or other UE connects to a wireless base station ("gNB") via RF signaling conducted between the UE and the gNB at one or more mmWave bands. Typically, the UE employs an array of antenna modules (e.g., a phased array) for the RF signaling, with the array comprising two or more antenna modules capable of conducting RF signaling at the appropriate frequency. Each antenna module includes one or more RF antennae, such as a path or dipole antenna, with either single- or dual-polarization. A transceiver employs transmit and receive channels for each antenna module, as well as providing frequency conversion between RF and IF (Intermediate Frequency). A modem, in turn, operates to convert digital data from an Application Processor (AP) to an IF signal for transmission, as well as to convert a received IF signal to corresponding digital data for consumption by the AP.

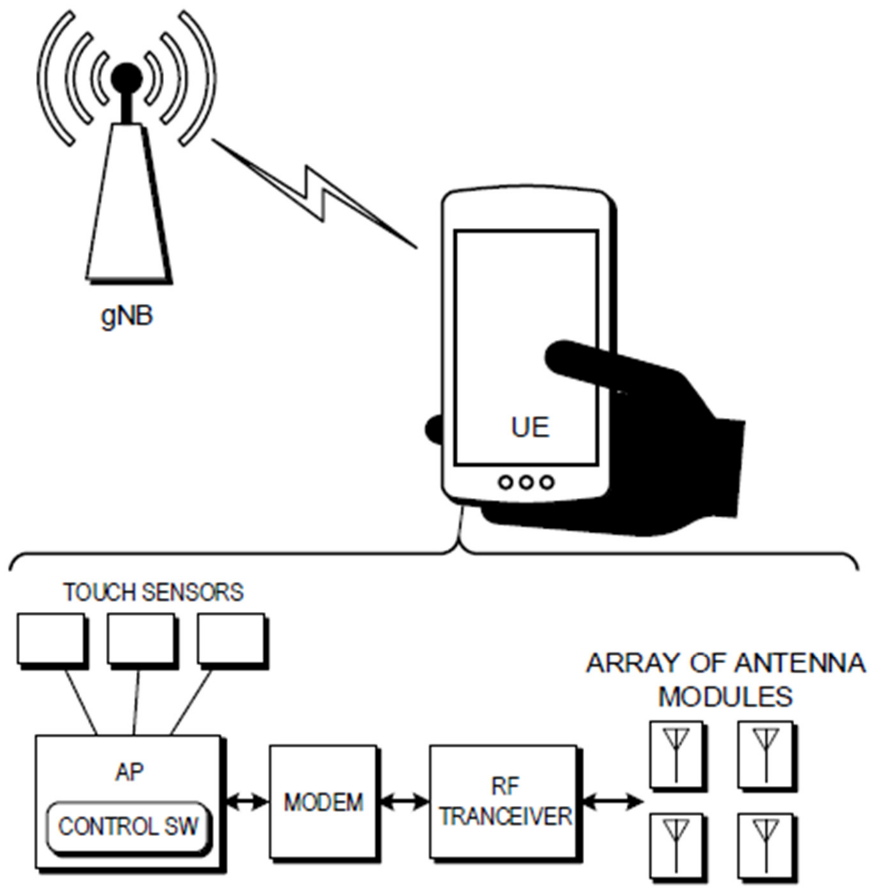

FIG. 1 – mmWave system

The use of an array of antenna modules enables beam steering with the intent to provide adequate Equivalent Isotropically Radiated Power (EIRP) regardless of the orientation of the UE. However, the user's handgrip of the UE, as well as positioning of the user's body between the UE and the gNB, often can result in blockage of one or both of the incoming and outgoing RF signals due to absorption or other attenuation of the RF signals by the hand or body of the user. Accordingly, as illustrated by FIG. 2 below and the corresponding description, the UE can employ a selective antenna disablement process to selectively disable those antenna modules affected by handgrip or body positioning and thus reduce the power consumption of the UE when impacted by handgrip or body positioning without substantially impacting RF signaling quality.

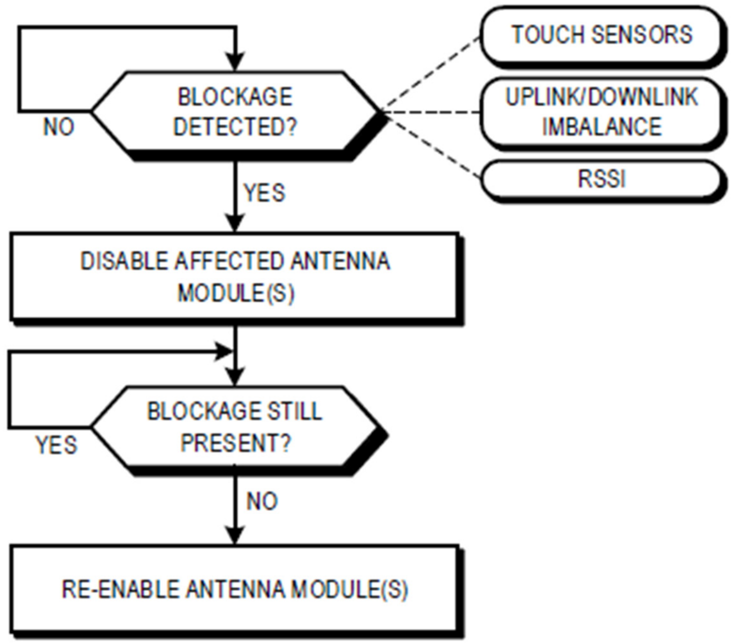

FIG. 2 – Selective Antenna Module Disablement Process

Following power-up or some other initiation event, the AP monitors the array of antenna modules to determine if a potential blockage of one or more of the antenna modules is present. This blockage can be the result of, for example, user handgrip, body or material blockage, a lack of line-of-sight between the gNB and the UE, and the like. The blockage, and the one or more antenna modules affected by the blockage, can be detected using any of a variety of techniques. For example, the UE can utilize one or more touch sensors (see FIG. 1) to detect a handgrip, and its positioning, and from this identify those antenna modules that are likely to be affected by the particular handgrip detected. For example, each touch sensor may be associated with one or more antenna modules based on proximity or location, and when contact with a touch sensor is detected, the associated one or more antenna modules are identified as affected by the handgrip. In the event that the UE does not employ touch sensors for this purpose, handgrip or body blockage can instead be detected through the periodic polling of the Received Signal Strength

Indicator (RSSI) parameter from each antenna module. Those antenna modules exhibiting an RSSI below a specified threshold or exhibiting an RSSI substantially below the RSSIs of other antenna modules can be thus identified as affected by blockage. A lack of line-of-sight between the gNB and the UE can be detected by, for example, detecting an uplink/downlink imbalance in one or more antenna modules, with each antenna module exhibiting this imbalance thus being identified as affected.

With a blockage detected and the one or more affected antenna modules identified, the AP then can signal the modem to temporarily disable the one or more affected antenna modules. To illustrate, the modem may employ control software (e.g., a driver) that provides an application programming interface (API) that is configured to receive a selective disablement message that the AP can use to specify which antenna modules are to be disabled (and which antenna modules are to remain enabled). For example, this message can take the form of a bitmask, with each bit position of the bitmask corresponding to a specific antenna module, with a value of "0" indicating that the corresponding antenna module is to be enabled (or remain enabled) and a value of "1" indicating that the corresponding antenna module is to be disabled (or remain disabled).

After a specified time (e.g., 250 milliseconds) indicated by, for example, a countdown timer, or in response to some other trigger following the process of selectively disabling the affected antenna module(s), the AP reassesses the status of the array of antenna modules to determine whether a blockage is still present. Again, touch sensors or RSSIs can be used to detect handgrip or body blockages and uplink/downlink imbalances can be used to detect lack of line-of-sight. If the blockage is still present, the AP maintains the current selective enablement/disablement arrangement for the antenna modules of the array. Otherwise, if the blockage is no longer present, then the AP re-enables the previously-disabled antenna modules by, for example, sending another message to the modem via the API, with this message having a bitmask that enables all antenna modules.

Through the above-described approach of identifying antenna modules affected by a blockage and temporarily disabling the affected antenna modules while the blockage is present, the UE can save considerable power as the UE can avoid transmitting at a higher power to overcome the higher attenuation of the signal caused by the blockage. Moreover, by disabling antenna modules affected by handgrip or other similar blockages, the UE can avoid continuing to scan for signaling or conduct calls via the affected antenna modules, which also results in significant power savings.

References

1. U.S. Patent Application Publication No. 20180269954A1, entitled " Sensor-driven systems and methods to activate and deactivate beam scanning" and filed on 16 March 2016.
2. U.S. Patent Application Publication No. 20190393944A1, entitled " Method and apparatus for sensor assisted beam selection, beam tracking, and antenna module selection" and filed on 22 June 2018.