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(54) **Title:** CLIENT DEVICE AND NETWORK ACCESS NODE FOR MEASUREMENTS IN POWER SAVING MODE

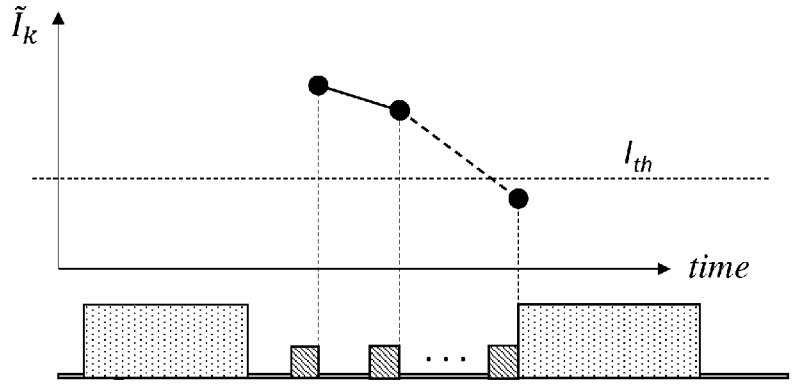


Fig. 10

(57) **Abstract:** The invention relates to improving mobility and handover when a client device (100) is using a power saving mode. The client device (100) can operate in a power saving mode and in a non- power saving mode. In the power saving mode the client device (100) performs signal quality measurements of reference signals. If the signal quality drops during the power saving mode, the client device (100) switches to the non-power saving mode and e.g. makes measurements associated with handover or other mobility procedures. Thereby, late handover reporting can be avoided and the risk of handover failure can be reduced. The client device (100) can perform the signal quality measurements based on a measurement configuration received by the client device (100) from a network access node (300). Therefore, the invention also relates to a network access node (300) configured to interwork with the client device (100).

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CLIENT DEVICE AND NETWORK ACCESS NODE FOR MEASUREMENTS IN POWER SAVING MODE

Technical Field

The invention relates to a client device and a network access node for measurements in power saving mode. Furthermore, the invention also relates to corresponding methods and a computer program.

Background

The power saving concept is one of the major topics in telecommunication today. In telecommunication and especially in 5G New Radio (NR) a lot of effort are spent on trying to decrease the power consumption of the user equipment (UE) and hence increasing the battery life. The two most promising power saving techniques proposed for NR are: wake-up signal (WUS) and bandwidth part (BWP). However, power saving techniques usually has a negative impact on the correctness of mobility measurements and handover times, since a UE´s in power saving mode has limited access to reference signals (RSs) either in time or frequency.

The main idea of the WUS concept is that a network access node, such as a base station (BS), sends a WUS to a UE when the network access node has something to transmit to the UE. Based on the WUS the UE should wake-up from a low power state, e.g. a sleep state, and listen to the physical dedicated control channel (PDCCH) after a predefine time. To detect the WUS, the UE only activates the minimum functionality or use a low power wake-up receiver. Hence, the power consumption of the UE can be decreased, since the UE does not have to wake-up for “empty” OnDurations in discontinuous reception (DRX), i.e. OnDurations where the network access node does not have anything to transmit to the UE.

The BWP concept is based on a BWP semi-statically configured to a UE in radio resource control (RRC) connected mode. When a UE is configured with a BWP, the BWP can be utilized for energy saving purposes instead of a wake-up receiver. Several activation options for the BWP have been suggested, such as: network based BWP switching, pattern based BWP switching, a combination of these two, or consideration of activity and inactivity. With the network based BWP switching the network sends a switching command to the UE after which the UE moves from a low power state to a high power state or vice versa. In the pattern based BWP switching the moving between the low and high power states are defined by timers which are sent to the UE beforehand. This can be done by utilizing e.g. RRC messages.

Summary

An objective of embodiments of the invention is to provide a solution which mitigates or solves the drawbacks and problems of conventional solutions.

The above and further objectives are solved by the subject matter of the independent claims. Further advantageous embodiments of the invention can be found in the dependent claims.

According to a first aspect of the invention, the above mentioned and other objectives are achieved with a client device for a wireless communication system, the client device being configured to

measure a first received reference signal;

determine a signal quality based on the measured first received reference signal; and

switch from a first radio power consumption mode to a second radio power consumption mode when the determined signal quality is less than a signal quality threshold value, wherein the client device when operating in the first radio power consumption mode has a first power consumption and the client device when operating in the second radio power consumption mode has a second power consumption that is higher than the first power consumption.

The signal quality can in this disclosure be understood to be an indication of the quality of the a first received reference signal determined from the measurement results obtained from the measurements of the first received reference signal.

An advantage of the client device according to the first aspect is that when the client device is in the first radio power consumption mode the client device may not be able to perform needed handover measurements or other mobility procedures and therefore has to switch to the second radio power consumption mode. Therefore, when the signal quality is decreasing rapidly the client device in the first radio power consumption mode will switch to the second radio power consumption mode according to the present solution. Thereby, mobility procedures, such as handover and random access can be improved compared to conventional solutions.

In an implementation form of a client device according to the first aspect, the client device is further configured to

determine a time instance when to switch from the first radio power consumption mode to the second radio power consumption mode based on the determined signal quality and a reference signal quality;

switch from the first radio power consumption mode to the second radio power consumption mode when the determined time instance is less than a time instance threshold value.

An advantage with this implementation form is that the determined time instance enables timely handover process and reduces the possibility for the handover failures.

In an implementation form of a client device according to the first aspect, the client device is further configured to

determine the time instance based on the determined signal quality, the reference signal quality and their respective variance.

An advantage with this implementation form is that the accuracy of the determined time instance during the first radio power consumption mode is considerably improved.

In an implementation form of a client device according to the first aspect, the client device is further configured to

determine the time instance based on a filtered combination of the determined signal quality, the reference signal quality and their respective variance.

An advantage with this implementation form is that it reduces the variability of the determined time instance which in turn enables the timely decision on switching from the first radio power consumption mode to the second radio power consumption mode.

In an implementation form of a client device according to the first aspect, the client device is further configured to

measure a second received reference signal when operating in the second radio power consumption mode;

determine the reference signal quality based on the measured second received reference signal.

An advantage with this implementation form is that when measuring the second received reference signal the total number of measured reference signals during the second radio power consumption mode is significantly higher than when measuring the reference signals during first radio power consumption mode. This is because in the first radio power consumption mode the number of reference signals to be measured in time and in frequency are limited in order to save energy. Therefore, when computing the average reference signal quality the number

of samples is higher and the accuracy is better in the second radio power consumption mode compared to measurements during the first radio power consumption mode.

In an implementation form of a client device according to the first aspect, the client device is further configured to

receive a first control message from a network access node, wherein the first control message comprises a measurement configuration;

measure the first received reference signal according to the measurement configuration.

An advantage with this implementation form is that by sending the measurement configuration to the client device the network access node is able to control and coordinate the reference signals the client device is measuring. This is especially important in cases when the client device has no knowledge about the reference signals it needs to measure or only has partial knowledge about the reference signals to measure. Additionally, by sending the measurement configuration the network access node is able to control the quality of the handover process, that is to reduce the handover failures and reduce the continuous change of the serving network access node, i.e. ping pong effect. The length of the first radio power consumption mode is set by the network access node and that effects the quality of the handover measurements. The longer the first radio power consumption mode is the higher possibility there is to have significant signal quality degradation during the first radio power consumption mode which in turn increases the probability of handover failure. In that case the network access node is able to improve the measurements by sending an appropriate updated measurement configuration.

In an implementation form of a client device according to the first aspect, the measurement configuration comprises at least one of: a measurement frequency, a measurement bandwidth, a frequency-hopping pattern, a measurement duration, a measurement periodicity, a first reference signal to measure, a transmission timing of a first reference signal to measure, the signal quality threshold value, a filtering parameter, and an activation of measurement in a first radio power consumption mode.

An advantage with this implementation form is that the network access node is able to coordinate all significant aspects of the reference signal measurements during the first radio power consumption mode and is therefore capable of control the power consumption as well as the quality of handovers.

In an implementation form of a client device according to the first aspect, the client device is further configured to

determine a signal quality of a radio link between the client device and the network access node;

generate a second control message comprising an indication of the determined signal quality of the radio link;

transmit the second control message to the network access node.

An advantage with this implementation form is that when the network access node is able to adjust the measurement configuration according to changes in the signal quality the client device is able to make adequate and appropriate measurements for handover or other mobility purposes.

In an implementation form of a client device according to the first aspect, the client device is further configured to

receive an updated first control message from the network access node in response to the transmission of the second control message, wherein the updated first control message comprises an updated measurement configuration;

measure the first received reference signal according to the updated measurement configuration.

An advantage with this implementation form is that when the network access node is able to send an updated measurement configuration message to the client device in the case of changes in signal quality, changes in reference signal arrangements of the serving access node or in other, neighbouring access nodes. Thereby, the client device is able to measure correct reference signals and to make correct decisions based on measurement due to the updated measurement configuration.

In an implementation form of a client device according to the first aspect, the client device is further configured to

perform, after having switched on from the first radio power consumption mode to the second radio power consumption mode, a mobility measurement.

An advantage with this implementation form is that mobility procedures, such as handover and random access can be improved due to the fact that the mobility measurement is performed by the client device in the second radio power consumption mode compared to having performed in the first radio power consumption mode.

In an implementation form of a client device according to the first aspect, the first radio power consumption mode is associated with a first radio configuration and the second radio power consumption mode is associated with a second radio configuration, respectively, of the client device.

An advantage with this implementation form is that the first radio configuration is a limited configuration compared to the second radio configuration in respect of power consumption. The advantage of using limited radio configuration is to reduce the power consumption in the client device.

According to a second aspect of the invention, the above mentioned and other objectives are achieved with a network access node for a wireless communication system, the network access node being configured to

determine a measurement configuration to be used by a client device for measuring a first reference signal when the client device operates in a first radio power consumption mode having a first power consumption, wherein the first power consumption is lower than a second power consumption of a second radio power consumption mode of the client device;

generate a first control message comprising the measurement configuration;

transmit the first control message to the client device.

An advantage of the network access node according to the second aspect is that by sending the measurement configuration to the client device the network access node is able to control and coordinate the reference signals the client device is measuring. This is especially important in cases where the client device has no knowledge about the reference signals it needs to measure or only has partial knowledge about the reference signals to measure. Additionally, by sending the measurement configuration the network access node is able to control the quality of the handover process, that is to reduce the handover failures and reduce the continuous change of the serving network node, i.e. ping pong effect. The length of the first radio power consumption mode is set by the network access node and that effects the quality of the handover measurements. The longer the first radio power consumption mode is the higher possibility there is to have significant signal quality degradation during the first radio power consumption mode which in turn increases the probability of handover failure. In that case the network access node is able to improve the measurements by sending an appropriate updated measurement configuration.

In an implementation form of a network access node according to the second aspect, the measurement configuration comprises at least one of: a measurement frequency, a measurement bandwidth, a frequency-hopping pattern, a measurement duration, a measurement periodicity, a first reference signal to measure, a transmission timing of a first reference signal to measure, a signal quality threshold value, a filtering parameter, and an activation of measurement in a first radio power consumption mode.

An advantage with this implementation form is that the network access node is able to coordinate and control all significant aspects of the reference signal measurements during the first radio power consumption mode and is therefore capable of control the power consumption as well as the quality of handover or other mobility procedures.

In an implementation form of a network access node according to the second aspect, the network access node is further configured to

receive a second control message from the client device in response to transmission of the first control message, wherein the second control message comprises an indication of a signal quality of a radio link between the client device and the network access node;

determine an updated measurement configuration based on the signal quality of the radio link;

generate an updated first control message comprising the determined updated measurement configuration;

transmit the updated first control message to the client device.

An advantage with this implementation form is that when the network access node is able to send an updated measurement configuration to the client device in the case of changes in signal quality, changes in reference signal arrangements of the serving access node or in other, neighbouring access nodes. Thereby, the client device is able to measure correct reference signals and to make correct decisions based on measurement due to the updated measurement configuration.

According to a third aspect of the invention, the above mentioned and other objectives are achieved with a method for a client device, the method comprises

measuring a first received reference signal;

determining a signal quality based on the measured first received reference signal; and

switching from a first radio power consumption mode to a second radio power consumption mode when the determined signal quality is less than a signal quality threshold value, wherein the client device when operating in the first radio power consumption mode has

a first power consumption and the client device when operating in the second radio power consumption mode has a second power consumption that is higher than the first power consumption.

The method according to the third aspect can be extended into implementation forms corresponding to the implementation forms of the client device according to the first aspect. Hence, an implementation form of the method comprises the feature(s) of the corresponding implementation form of the client device.

The advantages of the methods according to the third aspect are the same as those for the corresponding implementation forms of the client device according to the first aspect.

According to a fourth aspect of the invention, the above mentioned and other objectives are achieved with a method for a network access node comprising the client device, the method comprises

determining a measurement configuration to be used by a client device for measuring a first reference signal when the client device operates in a first radio power consumption mode having a first power consumption, wherein the first power consumption is lower than a second power consumption of a second radio power consumption mode of the client device;

generating a first control message comprising the measurement configuration;

transmitting the first control message to the client device.

The method according to the fourth aspect can be extended into implementation forms corresponding to the implementation forms of the network access node according to the second aspect. Hence, an implementation form of the method comprises the feature(s) of the corresponding implementation form of the network access node.

The advantages of the methods according to the fourth aspect are the same as those for the corresponding implementation forms of the network access node according to the second aspect.

The invention also relates to a computer program, characterized in program code, which when run by at least one processor causes said at least one processor to execute any method according to embodiments of the invention. Further, the invention also relates to a computer program product comprising a computer readable medium and said mentioned computer program, wherein said computer program is included in the computer readable medium, and comprises of one or more from the group: ROM (Read-Only Memory), PROM (Programmable

ROM), EPROM (Erasable PROM), Flash memory, EEPROM (Electrically EPROM) and hard disk drive.

Further applications and advantages of the embodiments of the invention will be apparent from the following detailed description.

Brief Description of the Drawings

The appended drawings are intended to clarify and explain different embodiments of the invention, in which:

- Fig. 1 shows a client device according to an example of the invention;
- Fig. 2 shows a method according to an example of the invention;
- Fig. 3 shows a network access node according to an example of the invention;
- Fig. 4 shows a method according to an example of the invention;
- Fig. 5 shows a wireless communication system according to an example of the invention;
- Fig. 6 shows a flow chart of a method according to an example of the invention;
- Fig. 7 shows measurement opportunities in a first radio power consumption mode and in a second first radio power consumption mode according to an example of the invention;
- Fig. 8 shows measurement opportunities in frequency domain according to an example of the invention;
- Fig. 9 shows estimations of a filtered signalling quality according to an example of the invention;
- Fig. 10 shows comparison of a filtered signalling quality to a signal quality threshold according to an example of the invention;
- Fig. 11 shows an estimation of a time instance according to an example of the invention; and
- Fig. 12 shows signalling between a network access node and a client device according to an example of the invention.

Detailed Description

Fig. 1 shows a client device 100 according to an embodiment of the invention. In the embodiment shown in Fig. 1, the client device 100 comprises a processor 102, a transceiver 104 and a memory 106. The processor 102 is coupled to the transceiver 104 and the memory 106 by communication means 108 known in the art. The client device 100 further comprises an antenna 110 coupled to the transceiver 104, which means that the client device 100 is configured for wireless communications in a wireless communication system.

That the client device 100 is configured to perform certain actions should in this disclosure be understood to mean that the client device 100 comprises suitable means, such as e.g. the processor 102 and the transceiver 104, configured to perform said actions.

The client device 100 is configured to measure a first received reference signal 502 and determine a signal quality based on the measured first received reference signal 502. The client device 100 is further configured to switch from a first radio power consumption mode P1 to a second radio power consumption mode P2 when the determined signal quality is less than a signal quality threshold value. When the client device 100 is operating in the first radio power consumption mode P1 the client device 100 has a first power consumption, and when the client device 100 is operating in the second radio power consumption mode P2 the client device 100 has a second power consumption that is higher than the first power consumption.

Fig. 2 shows a flow chart of a corresponding method 200 which may be executed in a client device 100, such as the one shown in Fig. 1. The method 200 comprises measuring 202 a first received reference signal 502 and determining 204 a signal quality based on the measured first received reference signal 502. The method 200 further comprises switching 206 from a first radio power consumption mode P1 to a second radio power consumption mode P2 when the determined signal quality is less than a signal quality threshold value. As previously described, when the client device 100 is operating in the first radio power consumption mode P1 the client device 100 has a first power consumption, and when the client device 100 is operating in the second radio power consumption mode P2 the client device 100 has a second power consumption that is higher than the first power consumption.

Fig. 3 shows a network access node 300 according to an embodiment of the invention. In the embodiment shown in Fig. 3, the network access node 300 comprises a processor 302, a transceiver 304 and a memory 306. The processor 302 is coupled to the transceiver 304 and the memory 306 by communication means 308 known in the art. The network access node 300 may be configured for both wireless and wired communications in wireless and wired communication systems, respectively. The wireless communication capability is provided with an antenna 310 coupled to the transceiver 304, while the wired communication capability is provided with a wired communication interface 312 coupled to the transceiver 304.

That the network access node 300 is configured to perform certain actions should in this disclosure be understood to mean that the network access node 300 comprises suitable

means, such as e.g. the processor 302 and the transceiver 304, configured to perform said actions.

The network access node 300 is configured to determine a measurement configuration to be used by a client device 100 for measuring a first reference signal 502 when the client device 100 operates in a first radio power consumption mode P1 having a first power consumption. The first power consumption is lower than a second power consumption of a second radio power consumption mode P2 of the client device 100. The network access node 300 is further configured to generate a first control message 512 comprising the measurement configuration and transmit the first control message 512 to the client device 100.

Fig. 4 shows a flow chart of a corresponding method 400 which may be executed in a network access node 300, such as the one shown in Fig. 3. The method 400 comprises determining 402 a measurement configuration to be used by a client device 100 for measuring a first reference signal 502 when the client device 100 operates in a first radio power consumption mode P1 having a first power consumption. The first power consumption is lower than a second power consumption of a second radio power consumption mode P2 of the client device 100. The method 400 further comprises generating 404 a first control message 512 comprising the measurement configuration and transmitting 406 the first control message 512 to the client device 100.

Fig. 5 shows a wireless communication system 500 according to an implementation. The wireless communication system 500 comprises a client device 100 and a network access node 300 configured to operate in the wireless communication system 500. For simplicity, the wireless communication system 500 shown in Fig. 5 only comprises one client device 100 and one network access node 300. However, the wireless communication system 500 may comprise any number of client devices 100 and any number of network access nodes 300 without deviating from the scope of the invention.

The client device 100 may operate in two different power consumption modes, a first radio power consumption mode P1 and a second radio power consumption mode P2. According to embodiments of the invention the first radio power consumption mode P1 may e.g. be a power saving mode where the client device 100 uses a special low power receiver or utilize the main modem in a special low power state, e.g. BWP or similar. The first radio power consumption mode P1 may be similar to a DRX sleep mode but have additional functionality such as the possibility to switch to a higher power consumption mode with higher frequency than with the DRX cycle or the possibility to use a narrowband, low power transceiver for measurements. In

the first radio power consumption mode P1 the client device 100 may not have a dedicated control signals allocated, since the network access node 300 may consider the client device 100 to be sleeping. Hence, the client device 100 may have negligible or limited data reception capability in the first radio power consumption mode P1. When the client device 100 is operating in the first radio power consumption mode P1, the client device 100 has a first power consumption. The second radio power consumption mode P2 may e.g. be a mode where the receiver of the client device 100 is switched on and the client device 100 is hence capable of receiving data from the network access node 300 and/or other network access nodes. In embodiments of the invention, the second radio power consumption mode P2 may correspond to a DRX on mode. When the client device 100 is operating in the second radio power consumption mode P2 the client device 100 has a second power consumption. Due to the different characteristics of the first radio power consumption mode P1 and second radio power consumption mode P2, the second power consumption is higher than the first power consumption. Furthermore, the first radio power consumption mode P1 may be associated with a first radio configuration of the client device 100 and the second radio power consumption mode P2 may associated with a second radio configuration of the client device 100. The first radio configuration and the second radio configuration may in embodiments of the invention be associated with DRX radio configurations. Also other radio configurations are possible which implies that the second power consumption is higher than the first power consumption.

The network access node 300 transmits reference signals upon which the client device 100 may perform measurements to determine the quality and the strength of the reference signals from the network access node 300. In the embodiments shown in Fig. 5, the network access node 300 transmits a first reference signal 502 and a second reference signal 504. Although shown as different reference signals in Fig. 5, the first reference signal 502 and the second reference signal 504 may in embodiments be partially the same reference signal such that the first reference signal 502 is comprised in the second reference signal 504. According to embodiments of the invention the client device 100 may measure the first reference signal 502 to determine a signal quality, when the client device 100 is operating in the first radio power consumption mode P1. Furthermore, the client device 100 may measure the second reference signal 504 to determine a reference signal quality, when the client device 100 is operating in the second radio power consumption mode P2. Hence, the client device 100 may perform measurements in both the first radio power consumption mode P1 and the second radio power consumption mode P2. The client device 100 may further use the measurement results to detect a sudden drop in the signal quality when operating in the first radio power consumption mode P1. A sudden drop in the signal quality may indicate that the client device 100 is in poor radio conditions and may have to perform a handover. Hence, the detected sudden drop in the

signal quality may trigger the client device 100 to switch from the first radio power consumption mode P1 to the second radio power consumption mode P2, to perform handover measurements. In this way, the client device 100 can avoid a late handover which may result in a radio link failure and increase the chance of a successful handover, even when the client device 100 is operating in a low power consumption mode. Hence, the client device 100 according to the invention can optimize handover performance while maintaining a low power consumption.

Fig. 6 shows a flow chart of a method 600 for switching from a first radio power consumption mode P1 to a second radio power consumption mode P2 according to an embodiment of the invention. The method 600 may be performed in a client device, such as e.g. the client device 100 shown in Fig. 1. In step 602, the client device 100 measures a first received reference signal 502. The first reference signal 502 may e.g. be secondary synchronization (SS) reference signals, channel state information (CSI) reference signals, or similar signal. According to embodiments of the invention the client device 100 may measure the first received reference signal 502 according to a measurement configuration received from a network access node 300, as will be described below with reference to Fig. 12. However, the measurement configuration may in embodiments instead be pre-defined in the client device 100 or obtained from another network node without deviating from the scope of the invention. The measurements of the first received reference signal 502 may e.g. provide the client device 100 with information about reference signal received power (RSRP), i.e. the averaged power contributions of the first reference signal 502, and received signal strength indicator (RSSI), i.e. the total wideband power contribution.

Based on the measurements of the first received reference signal 502 in step 602, the client device 100 determines a signal quality in step 604. In embodiments where the measurements of the first received reference signal 502 provides RSRP and RSSI information, the signal quality may e.g. be reference signal received quality (RSRQ) defined as the ratio of RSRP/RSSI. However, the signal quality may instead be determined using other information obtained from the measurements. Further details on how the signal quality can be determined will be described below with reference to Figs. 7-8.

In step 606, the client device 100 compares the determined signal quality with a signal quality threshold value. When the determined signal quality is less than, i.e. below, the signal quality threshold value the method 600 moves to step 608, where the client device 100 switches from the first radio power consumption mode P1 to the second radio power consumption mode P2.

Else, the method 600 returns to step 602, where the client device 100 continuous to measure the first received reference signal 502. Steps 602 to 606 are repeated as described above.

Step 606 may further comprise the determination of a time instance at which the switch from the first radio power consumption mode P1 to the second radio power consumption mode P2 should be performed. In other worlds, the client device 100 may in step 606 determine a time instance when to switch from the first radio power consumption mode P1 to the second radio power consumption mode P2. The time instance may be determined based on the determined signal quality and a reference signal quality. According to embodiments of the invention the client device 100 may determine the reference signal quality when operating in the second radio power consumption mode P2, as described below with reference to Fig. 7. In this case, the client device 100 may measure a second received reference signal 504 when operating in the second radio power consumption mode P2. The client device 100 may further determine the reference signal quality based on the measured second received reference signal 504.

In addition to the signal quality and the reference signal quality, the client device 100 may also consider information derived from the signal quality and a reference signal quality when determining the time instance. Hence, the client device 100 may determine the time instance based on the determined signal quality, the reference signal quality, and their respective variance. Furthermore, the client device 100 may determine the time instance based on a filtered combination of the determined signal quality, the reference signal quality and their respective variance. Further details on how the time instance may be determined will be described below with reference to Fig. 11.

In embodiments where step 606 comprise the determination of a time instance, the determined time instance is further compared to a time instance threshold value. When the determined time instance is less than, i.e. below, the time instance threshold value the method 600 moves to step 608, where the client device 100 switches from the first radio power consumption mode P1 to the second radio power consumption mode P2. Else the method 600 returns to step 602, where the client device 100 continuous to measure the first received reference signal 502.

After having switched from the first radio power consumption mode P1 to the second radio power consumption mode P2, the client device 100 may perform a mobility measurement. The mobility measurement may e.g. be handover measurements or similar.

Further details related to the determination of the signal quality, the reference signal quality and the time instance will now be described with reference to Figs. 7-11. Fig. 7 shows

measurement opportunities MOs of the client device 100 according to an embodiment of the invention. In the embodiment shown in Fig. 7, the client device 100 has been allocated several measurement opportunities MOs in the time and frequency domain, both in the first radio power consumption mode P1 and in the second radio power consumption mode P2. During measurement opportunities MOs in the first radio power consumption mode P1, the client device 100 measures the first received reference signal 502. In a similar way, during measurement opportunities MOs in the second radio power consumption mode P2, the client device 100 measures the second received reference signal 504.

When the client device 100 is operating in the second radio power consumption mode P2, the client device 100 may compute a reference signal quality I_{ref} of the second received reference signal 504 by estimating the average RSRP, RSRQ or similar over the period T_0 of the measurement opportunities MOs in the second radio power consumption mode P2, shown in Fig. 7. Thus, the reference signal quality I_{ref} may be computed using the following expression:

$$I_{ref} = \frac{1}{N_0}\sum_{i=1}^{N_0} I_i,$$

where I_i is either RSRP, RSRQ or similar in the physical radio block indexed i and N_0 is the number of physical radio blocks during time period T_0 used for the estimation over the second radio power consumption mode P2.

When the client device 100 is operating in the first radio power consumption mode P1, the client device 100 may measures the signal quality I_k of the first received reference signal 502 over the kth measurement opportunity MO in the first radio power consumption mode P1. Fig. 7 shows the periodicity T_3 and the duration T_4 of the measurement opportunities MOs in the first radio power consumption mode P1. Parameter T_2 is the offset between the end of the second radio power consumption mode P2 and the start of the first measurement opportunity MO in the first radio power consumption mode P1. The client device 100 may compute the signal quality I_k for the kth measurement opportunity MO in the first radio power consumption mode P1 using the following expression:

$$I_k = \frac{1}{N_k}\sum_{j}^{N_k} I_{k,j},$$

where $I_{k,j}$ is either RSRP, RSRQ or similar in the physical radio block j in the kth measurement opportunity MO in the first radio power consumption mode P1 and N_k is the number of physical

radio blocks measured over the *k*th measurement opportunity MO in the first radio power consumption mode P1.

The measurements can also be controlled in the frequency domain, as shown in Fig. 8. For example, the measurement opportunities MOs in the first radio power consumption mode P1 can be specified by defining the overall bandwidth for the measurement F_0, the center frequency $F_1(k)$ and bandwidths $F_2(k)$ for the *k*th measurement opportunity MO in the first radio power consumption mode P1. The bandwidth for the measurement F_0 and the center frequency $F_1(k)$ can be constant or e.g. time variant following some predefined frequency hopping pattern. If the physical location of the first reference signal 502 changes according to a pre-defined frequency hopping pattern the network access node 300 can synchronize the measurements of the client device 100 with the pattern. This approach allows the power consumption of both the network access node 300 and the client device 100 to be optimized.

In addition, the client device 100 can produce a filtered signal quality $\tilde{I}_k$ for the *k*th measurement opportunity MO in the first radio power consumption mode P1. To calculate the filtered signal quality $\tilde{I}_k$ the filter can utilize the signal quality I_k determined from measurements and the previous estimate $\tilde{I}_{k-1}$:

$$\tilde{I}_k = K_k I_k + (1 - K_k)\tilde{I}_{k-1}.$$

The filter can e.g. be a Kalman filter in which case K_k is called the Kalman gain and can be computed with an iterative algorithm or can be a moving average in which case K_k is constant (e.g. K_k=0.5). Fig. 9 shows the determined signal quality I_k and the filtered signal quality $\tilde{I}_k$ for the measurement opportunity MO in the first radio power consumption mode P1.

As previously described the client device 100 operating in the first radio power consumption mode P1 may determine whether to switch to the second radio power consumption mode P2 based on a determined signal quality and a signal quality threshold value. In embodiments, the signal quality may be determined as described above and hence correspond to the signal quality I_k or the filtered signal quality $\tilde{I}_k$. In this case, the client device 100 may compare the signal quality I_k or the filtered signal quality $\tilde{I}_k$ with a signal quality threshold value I_{th}. When the signal quality I_k or filtered signal quality $\tilde{I}_k$ is less than, i.e. below, the signal quality threshold value *Th1*, the client device 100 may switch to the second radio power consumption mode P2. In other words, a first rule may be used to determine whether to switch to the second radio

power consumption mode P2 from the first power consumption mode P1, where the first rule can be expressed as follows:

$$I_k;\ \widetilde{I_k} < I_{th}$$

Fig. 10 shows an embodiment where the filtered signal quality $\widetilde{I_k}$ is compared to the signal quality threshold value I_{th}. If the signal quality I_k drops instantly and the filtered signal quality $\widetilde{I_k}$ goes below the signal quality threshold value I_{th} the client device 100 switches from the first radio power consumption mode P1 to the second radio power consumption mode P2, as shown in Fig. 10. After the switch to the second radio power consumption mode P2, the client device 100 may perform handover measurements according to known handover measurements procedures e.g. defined by standards. The handover measurements results may be used to determine whether a serving link change, e.g. a handover, a beam switching, serving network access node switching or similar, is needed.

On the other hand, if the filtered signal quality $\widetilde{I_k}$ stays above the signal quality threshold value I_{th}, the client device 100 performs a new set of measurements of the first reference signal 502 in the next measurement opportunity MO in the first radio power consumption mode P1. The maximum time the client device 100 stays in the first radio power consumption mode P1 may be controlled by a first timer. In embodiments, the first timer may be based on DRX parameters and e.g. correspond to a sleep period of the DRX cycle. When the first timer expires, the client device 100 switches from the first radio power consumption mode P1 to the second radio power consumption mode P2. Hence, if the first rule is not fulfilled after any of the measurement opportunity MO in the first radio power consumption mode P1, the client device 100 stays in the first radio power consumption mode P1 until such a timer expires. Upon expiry of the first timer the client device 100 switches to the second radio power consumption mode P2. The client device 100 stays in the second radio power consumption mode P2 until a second timer expires when no handover event is triggered in the second radio power consumption mode P2. In embodiments, the second timer may be based on DRX parameters and e.g. correspond to an on-duration of the DRX cycle or inactivity timers. Furthermore, the total length of the second radio power consumption mode P2 may be affected e.g. by the PDCCH allocation due to incoming packet. Upon expiry of the second timer the client device 100 switches from the second radio power consumption mode P2 to the first radio power consumption mode P1. At this stage, the client device 100 may further compute a new value for the reference signal quality I_{ref}.

The time instance when to switch from the first radio power consumption mode P1 to the second radio power consumption mode P2 may be determined by the client device 100 based

on the determined signal quality and the reference signal quality, as previously described with reference to Fig. 6. In embodiments, the signal quality and the reference signal quality may be determined as described above. Hence, the signal quality may correspond to the signal quality I_k or the filtered signal quality $\widetilde{I_k}$ and the reference signal quality may correspond to the reference signal quality I_{ref}.

Fig. 11 shows the determination of the time instance according to an embodiment of the invention. When the client device 100 is operating in the second radio power consumption mode P2, the client device 100 can estimate the reference signal quality I_{ref} with high accuracy, i.e. with low variance. In the first radio power consumption mode P1 on the other hand the accuracy is typically lower, i.e. the variance is larger, as the number of measurement samples per measurement opportunity MO in the first radio power consumption mode P1 may be small. This is due to that the measurement opportunities MOs in the first radio power consumption mode P1 typically have a short duration T_4 and a long periodicity T_3, as shown in Fig. 7, to reduce the power consumption. With a short duration T_4 and a long periodicity T_3 the power consumption will be low but the variance of the determined signal quality I_k or filtered signal quality $\widetilde{I_k}$ will be high. The client device 100 may estimate the variance of the filtered signal quality $\widetilde{I_k}$ in the first radio power consumption mode P1 using the measurement samples. According to embodiments of the invention, the variance in the first radio power consumption mode P1 and the second radio power consumption mode P2 may be used in a Kalman filtering model to determine the time instance when to switch from the first radio power consumption mode P1 to the second radio power consumption mode P2, as shown in Fig. 11. Mentioned Fig. 11 shows the prediction of an estimated time until the time instance T_k occurs based on high and low variance of the filtered signal quality $\widetilde{I_k}$. The client device 100 may need a preparation time T_p before being able to start handover measurements in the second radio power consumption mode P2, e.g. due to modem ramp-up time and synchronization time. Hence, the client device 100 may determine a time for starting the modem switch based on the estimated time until the time instance T_k and the preparation time T_p. The client device 100 may determine to switch to the second radio power consumption mode P2, if the preparation time T_p is longer than the estimated time until the time instance T_k, i.e. based on the following comparison:

$$T_p > T_k.$$

The estimated time until the time instance T_k is the time $(i-k)\cdot T_3$ estimated for the kth measurement opportunity MO in the first radio power consumption mode P1 for which the filtered prediction $\hat{I}_{i(i>k)}$ falls below the signal quality threshold value I_{th}. The more time has

passed from the switch to the first radio power consumption mode P1 the lower the accuracy of the estimation of the time until the time instance T_k will be. Therefore, the measurement duration may be function of k. Using a model this would mean that $T_3(k)=T_{30}+a\times(k-1)$ where k is the index of the measurement opportunity MO in the first radio power consumption mode P1, T_{30} is the duration of the first measurement opportunity MO in the first radio power consumption mode P1 and a is a parameter describing the increment.

As previously mentioned, the client device 100 may measure the first received reference signal 502 according to a measurement configuration received from a network access node 300. The network access node 300 may further provide the client device 100 with the thresholds used by the client device 100 to determine when to switch to the second radio power consumption mode P2. According to embodiments of the invention the network access node 300 may provide the measurement configuration and/or the thresholds to the client device 100 in a first control message 512.

Fig. 12 shows the signalling between the network access node 300 and the client device 100 according to such an embodiment. In step I in Fig. 12, the network access node 300 determines a measurement configuration and generates a first control message 512 comprising the measurement configuration. The measurement configuration is used by a client device 100 for measuring a first reference signal 502 when the client device 100 operates in a first radio power consumption mode P1. Therefore, the measurement configuration comprises the information needed by the client device 100 for measuring first reference signal 502 so as to be able to switch to the second power consumption mode P1 at the right time instance and under the correct conditions. Thereby, a network controlled measurement configuration is provided that can be determined and tuned by the network. The measurement configuration comprises at least one of: a measurement frequency, a measurement bandwidth, a frequency-hopping pattern, a measurement duration, a measurement periodicity, a first reference signal 502 to measure, a transmission timing of a first reference signal 502 to measure, a signal quality threshold value, a filtering parameter, and an activation of measurement in a first radio power consumption mode P1.

Thus, the measurement configuration may provide information about the first reference signal 502, such as the physical frequency, time location, and modulation of the first reference signal 502, as well as information about how often and when the measurements should be performed. This information is provided alone or in combination by the measurement frequency, the measurement bandwidth, the frequency-hopping pattern, the measurement duration, the

measurement periodicity, the first reference signal 502 to measure, the transmission timing of a first reference signal 502 to measure.

The filtering parameter(s) may define how much the latest measured reference signal effect on the signal quality estimate. In that case the filtering parameter can be understood as filtering weights. The weight of the latest measurement result can be for example have the value *a* and the weight of the old filtered value can have the value (1-a). The updated filtered measurement result is therefore equal to: (1-*a*) * OFMR + *a* * LRM, wherein OFMR is an old or a previous filtered measurement result and LRM is the latest received measurement. A lower value of weight *a* corresponds to higher weight to old measurements which means that the variation of the signal has lower effect on the decision triggering of switching from the first power consumption mode to the second power consumption mode. This corresponds to lower probability to switch from the first power consumption mode to second power consumption mode due to instant high variation during the first power consumption mode.

Furthermore, the parameter activation of measurement in a first radio power consumption mode P1 may be an explicit indication or trigger from the network access node 300 to the client device 100 to start measurements according to the measurement configuration in a first radio power consumption mode P1. However, the activation of measurement in a first radio power consumption mode P1 may instead indicate a threshold value, e.g. related to signal strength such as RSRP, indicating at which signal strength the measurements according to the measurement configuration should be activated. By tuning the parameters in the measurement configuration, the power consumption and the measurement accuracy can be optimized.

The network access node 300 transmit the first control message 512 comprising the determined measurement configuration to the client device 100 in step II in Fig. 12. The client device 100 receive the first control message 512 from the network access node 300, and thereby the measurement configuration comprised in the first control message 512.

The client device 100 further uses the received measurement configuration when performing measurements on the first reference signal 502 when the client device 100 operates in a first radio power consumption mode P1. Hence, in step III in Fig. 12, the client device 100 measures the first received reference signal 502 according to the measurement configuration.

To synchronize the transmissions from the network access node 300 and measurements of the client device 100, the network access node 300 may re-configure the measurement parameters by transmitting an updated measurement configuration to the client device 100.

Thereby, a network controlled updating mechanism is provided. Therefore, in embodiments, an updated measurement configuration to the client device 100 may be transmitted to the client device 100 based on a signal quality of a radio link between the client device 100 and the network access node 300, as shown in Fig. 12 step IV to IX. In step IV in Fig. 12, the client device 100 determines a signal quality of a radio link between the client device 100 and the network access node 300, and generates a second control message 514 comprising an indication of the determined signal quality of the radio link. The indication can for example be any of formats Reference Signal Received Quality (RSRQ) or Channel Quality Indicator (CQI). The RSRQ corresponds to the Signal to Interference plus Noise ratio (SINR) of the reference signals. The Channel Quality Indicator (CQI) is used to report the channel quality to the network. The CQI is a scaled and quantized version of the SINR. It is to be noted that the indication of the determined signal quality of the radio link can be transmitted in other protocol formats. The second control message 514 is transmitted by the client device 100 to the network access node 300, as shown in step V in Fig. 12.

The network access node 300 receive the second control message 514 from the client device 100. The second control message 514 may in embodiments be received in response to the transmission of the first control message 512. The second control message 514 comprises the indication of the signal quality of the radio link between the client device 100 and the network access node 300, determined by the client device 100 in IV in Fig. 12. Based on the signal quality of the radio link the network access node 300 determines an updated measurement configuration and generates an updated first control message 512´ comprising the determined updated measurement configuration in step VI in Fig. 12. The updated first control message 512´ is transmitted by the network access node 300 to the client device 100, as shown in step VII in Fig. 12. The client device 100 receives the updated first control message 512´ from the network access node 300. In embodiments, the client device 100 may receive the updated first control message 512´ from the network access node 300 in response to the transmission of the second control message 514, wherein the updated first control message 512´ comprises an updated measurement configuration. In step VIII, the client device 100 measures the first received reference signal 502 according to the updated measurement configuration.

The client device 100 herein, may be denoted as a user device, a User Equipment (UE), a mobile station, an internet of things (IoT) device, a sensor device, a wireless terminal and/or a mobile terminal, is enabled to communicate wirelessly in a wireless communication system, sometimes also referred to as a cellular radio system. The UEs may further be referred to as mobile telephones, cellular telephones, computer tablets or laptops with wireless capability. The UEs in this context may be, for example, portable, pocket-storable, hand-held, computer-

comprised, or vehicle-mounted mobile devices, enabled to communicate voice and/or data, via the radio access network, with another entity, such as another receiver or a server. The UE can be a Station (STA), which is any device that contains an IEEE 802.11-conformant Media Access Control (MAC) and Physical Layer (PHY) interface to the Wireless Medium (WM). The UE may also be configured for communication in 3GPP related LTE and LTE-Advanced, in WiMAX and its evolution, and in fifth generation wireless technologies, such as New Radio.

The network access node 300 herein may also be denoted as a radio network access node, an access network access node, an access point, or a base station, e.g. a Radio Base Station (RBS), which in some networks may be referred to as transmitter, “gNB”, “gNodeB”, “eNB”, “eNodeB”, “NodeB” or “B node”, depending on the technology and terminology used. The radio network access nodes may be of different classes such as e.g. macro eNodeB, home eNodeB or pico base station, based on transmission power and thereby also cell size. The radio network access node can be a Station (STA), which is any device that contains an IEEE 802.11-conformant Media Access Control (MAC) and Physical Layer (PHY) interface to the Wireless Medium (WM). The radio network access node may also be a base station corresponding to the fifth generation (5G) wireless systems.

Furthermore, any method according to embodiments of the invention may be implemented in a computer program, having code means, which when run by processing means causes the processing means to execute the steps of the method. The computer program is included in a computer readable medium of a computer program product. The computer readable medium may comprise essentially any memory, such as a ROM (Read-Only Memory), a PROM (Programmable Read-Only Memory), an EPROM (Erasable PROM), a Flash memory, an EEPROM (Electrically Erasable PROM), or a hard disk drive.

Moreover, it is realized by the skilled person that embodiments of the client device 100 and the network access node 300 comprises the necessary communication capabilities in the form of e.g., functions, means, units, elements, etc., for performing the solution. Examples of other such means, units, elements and functions are: processors, memory, buffers, control logic, encoders, decoders, rate matchers, de-rate matchers, mapping units, multipliers, decision units, selecting units, switches, interleavers, de-interleavers, modulators, demodulators, inputs, outputs, antennas, amplifiers, receiver units, transmitter units, DSPs, MSDs, TCM encoder, TCM decoder, power supply units, power feeders, communication interfaces, communication protocols, etc. which are suitably arranged together for performing the solution.

Especially, the processor(s) of the client device 100 and the network access node 300 may comprise, e.g., one or more instances of a Central Processing Unit (CPU), a processing unit, a processing circuit, a processor, an Application Specific Integrated Circuit (ASIC), a microprocessor, or other processing logic that may interpret and execute instructions. The expression "processor" may thus represent a processing circuitry comprising a plurality of processing circuits, such as, e.g., any, some or all of the ones mentioned above. The processing circuitry may further perform data processing functions for inputting, outputting, and processing of data comprising data buffering and device control functions, such as call processing control, user interface control, or the like.

Finally, it should be understood that the invention is not limited to the embodiments described above, but also relates to and incorporates all embodiments within the scope of the appended independent claims.

Claims

1. A client device (100) for a wireless communication system (500), the client device (100) being configured to

measure a first received reference signal (502);

determine a signal quality based on the measured first received reference signal (502); and

switch from a first radio power consumption mode (P1) to a second radio power consumption mode (P2) when the determined signal quality is less than a signal quality threshold value, wherein the client device (100) when operating in the first radio power consumption mode (P1) has a first power consumption and the client device (100) when operating in the second radio power consumption mode (P2) has a second power consumption that is higher than the first power consumption.

2. The client device (100) according to claim 1, configured to

determine a time instance when to switch from the first radio power consumption mode (P1) to the second radio power consumption mode (P2) based on the determined signal quality and a reference signal quality;

switch from the first radio power consumption mode (P1) to the second radio power consumption mode (P2) when the determined time instance is less than a time instance threshold value.

3. The client device (100) according to claim 2, configured to

determine the time instance based on the determined signal quality, the reference signal quality and their respective variance.

4. The client device (100) according to claim 3, configured to

determine the time instance based on a filtered combination of the determined signal quality, the reference signal quality and their respective variance.

5. The client device (100) according to any of claims 2 to 4, configured to

measure a second received reference signal (504) when operating in the second radio power consumption mode (P2);

determine the reference signal quality based on the measured second received reference signal (504).

6. The client device (100) according to any of the proceeding claims, configured to

receive a first control message (512) from a network access node (300), wherein the first control message (512) comprises a measurement configuration;

measure the first received reference signal (502) according to the measurement configuration.

7. The client device (100) according to claim 6, wherein the measurement configuration comprises at least one of: a measurement frequency, a measurement bandwidth, a frequency-hopping pattern, a measurement duration, a measurement periodicity, a first reference signal to measure, a transmission timing of a first reference signal to measure, the signal quality threshold value, a filtering parameter, and an activation of measurement in a first radio power consumption mode (P1).

8. The client device (100) according to claim 6 or 7, configured to

determine a signal quality of a radio link between the client device (100) and the network access node (300);

generate a second control message (514) comprising an indication of the determined signal quality of the radio link;

transmit the second control message (514) to the network access node (300).

9. The client device (100) according to claim 8, configured to

receive an updated first control message (512´) from the network access node (300) in response to the transmission of the second control message (514), wherein the updated first control message (512´) comprises an updated measurement configuration;

measure the first received reference signal (502) according to the updated measurement configuration.

10. A network access node (300) for a wireless communication system (500), the network access node (300) being configured to

determine a measurement configuration to be used by a client device (100) for measuring a first reference signal (502) when the client device (100) operates in a first radio power consumption mode (P1) having a first power consumption, wherein the first power consumption is lower than a second power consumption of a second radio power consumption mode (P2) of the client device (100);

generate a first control message (512) comprising the measurement configuration;

transmit the first control message (512) to the client device (100).

11. The network access node (300) according to claim 10, wherein the measurement configuration comprises at least one of: a measurement frequency, a measurement bandwidth, a frequency-hopping pattern, a measurement duration, a measurement periodicity, a first reference signal to measure, a transmission timing of a first reference signal to measure, a signal quality threshold value, a filtering parameter, and an activation of measurement in a first radio power consumption mode (P1).

12. The network access node (300) according to claim 10 or 11, configured to

receive a second control message (514) from the client device (100) in response to transmission of the first control message (512), wherein the second control message (514) comprises an indication of a signal quality of a radio link between the client device (100) and the network access node (300);

determine an updated measurement configuration based on the signal quality of the radio link;

generate an updated first control message (512´) comprising the determined updated measurement configuration;

transmit the updated first control message (512´) to the client device (100).

13. A method (200) for a client device (100), the method (200) comprising

measuring (202) a first received reference signal (502);

determining (204) a signal quality based on the measured first received reference signal (502); and

switching (206) from a first radio power consumption mode (P1) to a second radio power consumption mode (P2) when the determined signal quality is less than a signal quality threshold value, wherein the client device (100) when operating in the first radio power consumption mode (P1) has a first power consumption and the client device (100) when operating in the second radio power consumption mode (P2) has a second power consumption that is higher than the first power consumption.

14. A method (400) for a network access node (300), the method (400) comprising

determining (402) a measurement configuration to be used by a client device (100) for measuring a first reference signal (502) when the client device (100) operates in a first radio power consumption mode (P1) having a first power consumption, wherein the first power consumption is lower than a second power consumption of a second radio power consumption mode (P2) of the client device (100);

generating (404) a first control message (512) comprising the measurement configuration;

transmitting (406) the first control message (512) to the client device (100).

15. A computer program with a program code for performing a method according to claim 13 or 14 when the computer program runs on a computer.

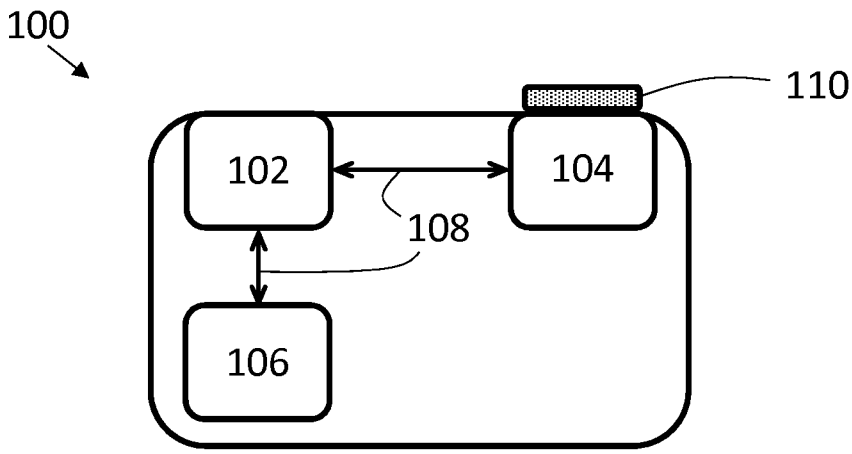


Fig. 1

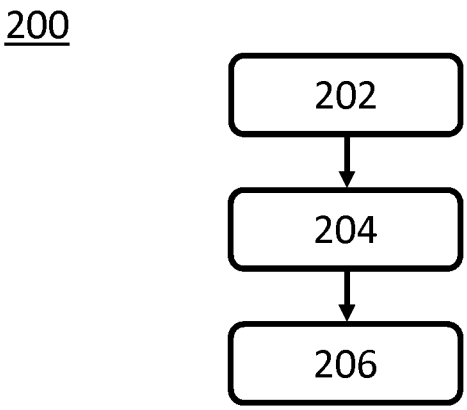


Fig. 2

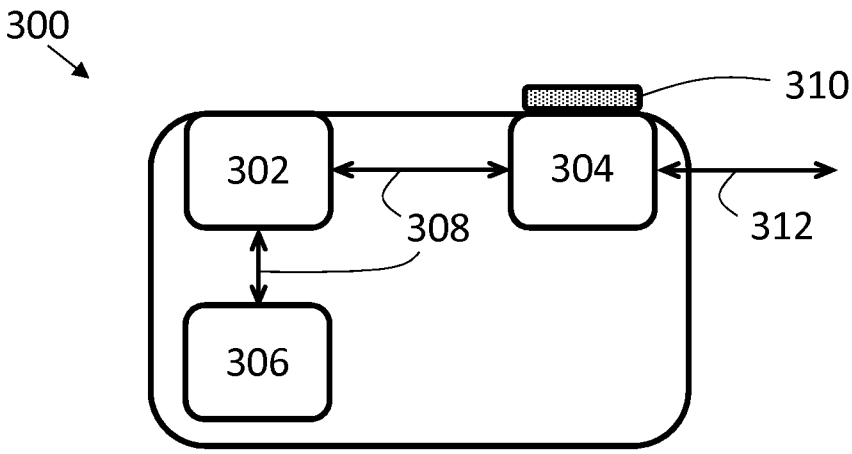


Fig. 3

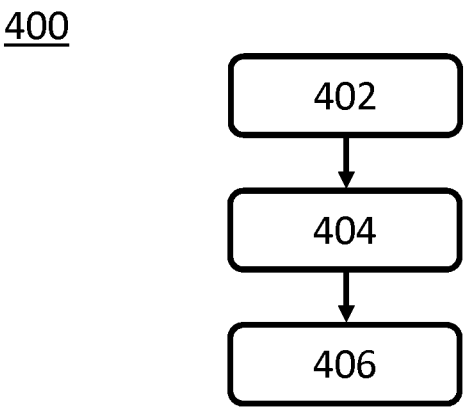


Fig. 4

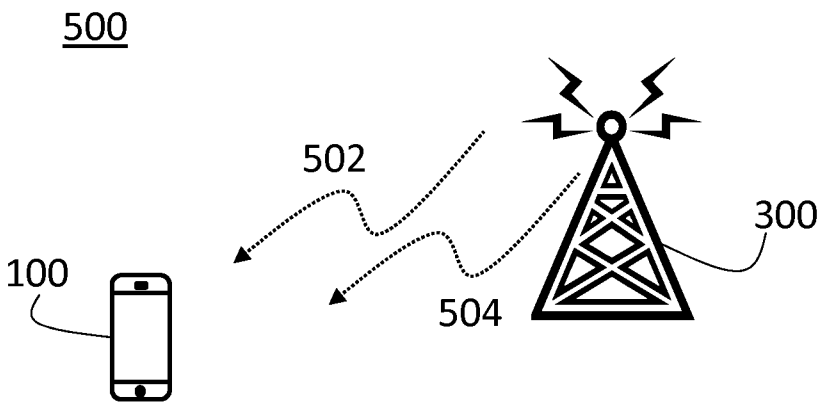


Fig. 5

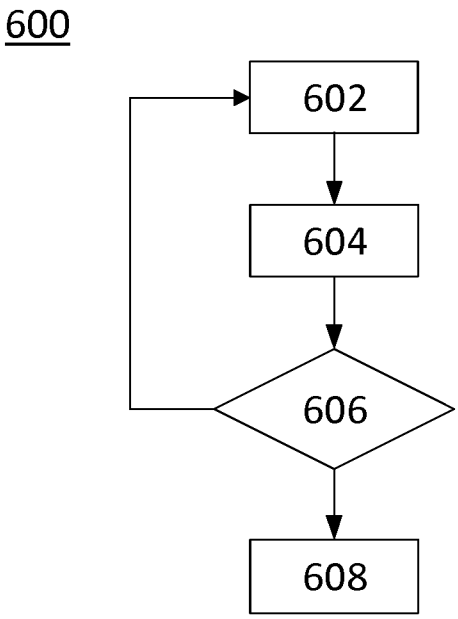


Fig. 6

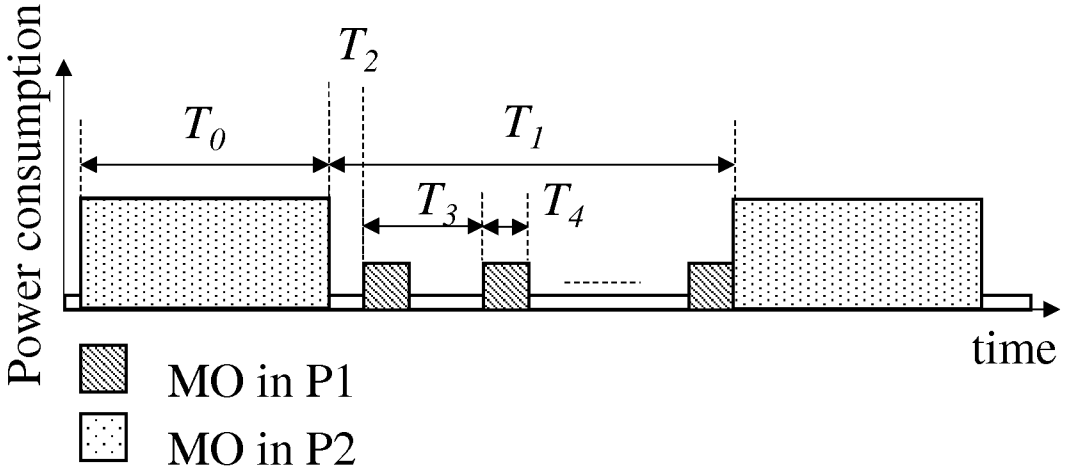

Power consumption
T_0
T_2
T_1
T_3
T_4
time
MO in P1
MO in P2

Fig. 7

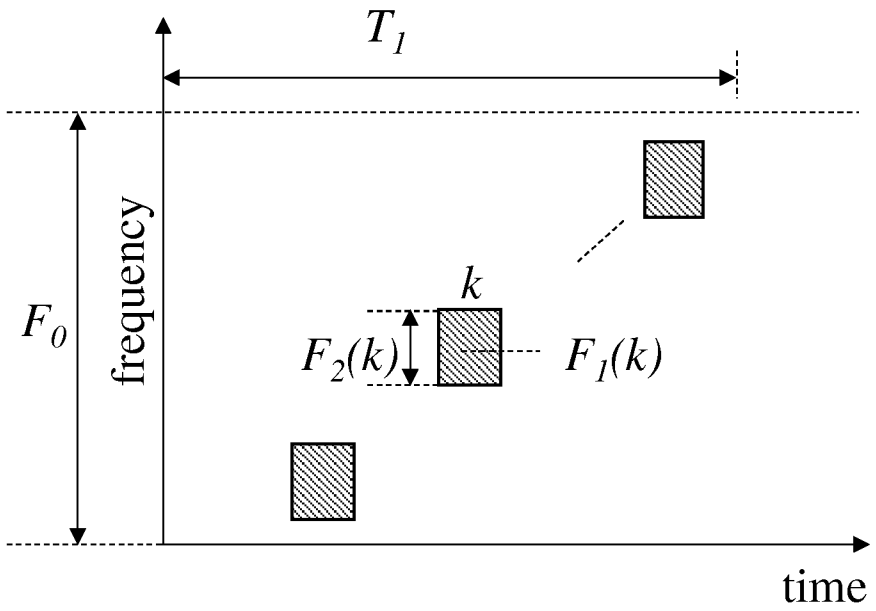

T_1
F_0
frequency
k
$F_2(k)$
$F_1(k)$
time

Fig. 8

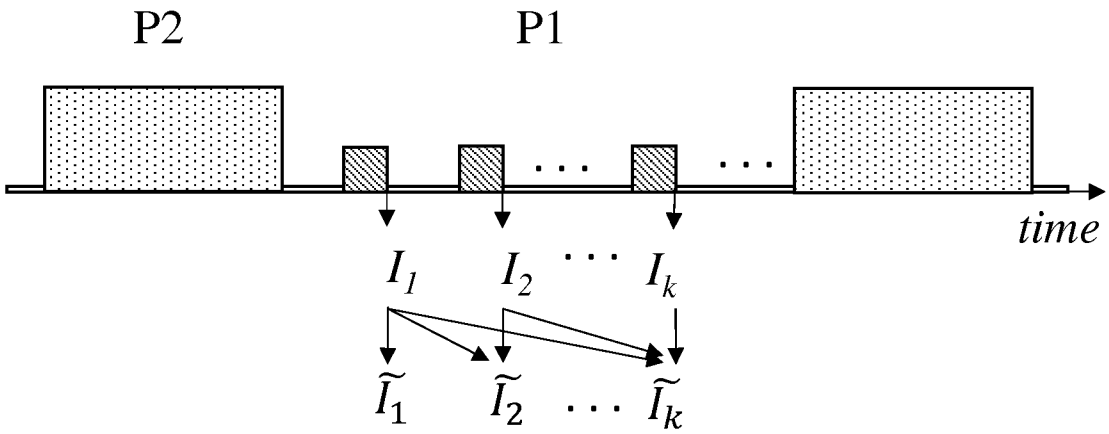


Fig. 9

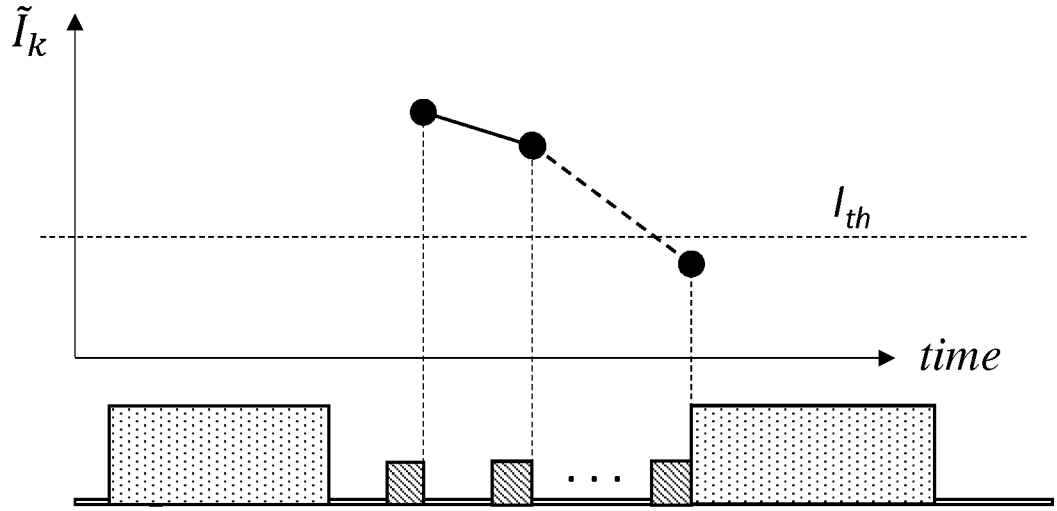


Fig. 10

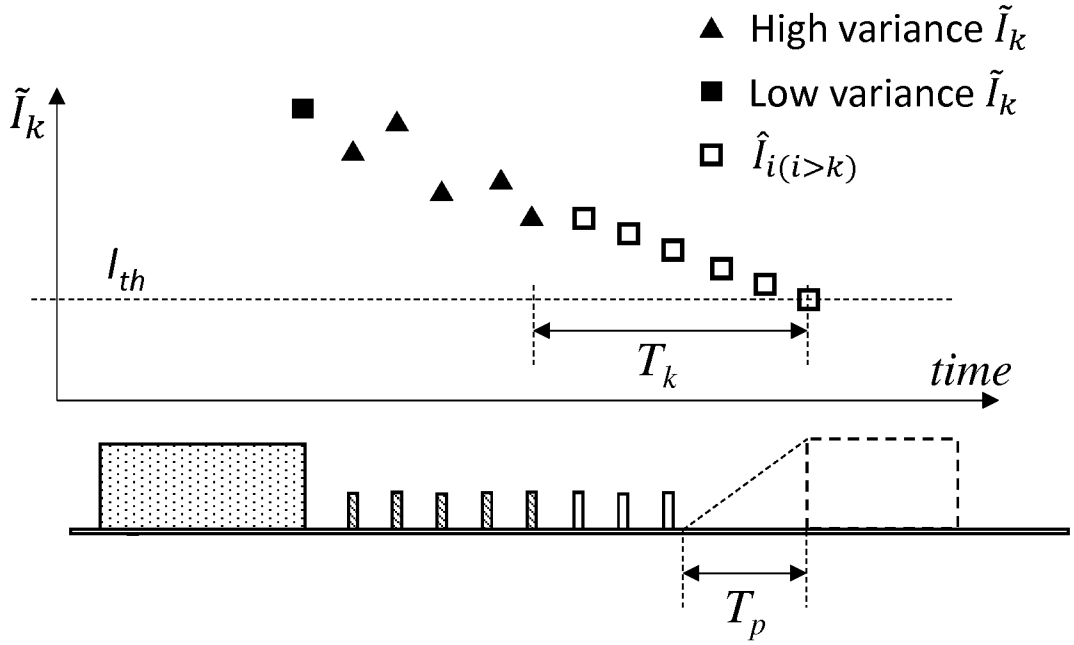

High variance $\tilde{I}_k$
Low variance $\tilde{I}_k$
$\hat{I}_{i(i>k)}$
$\tilde{I}_k$
I_{th}
T_k
time
T_p

Fig. 11

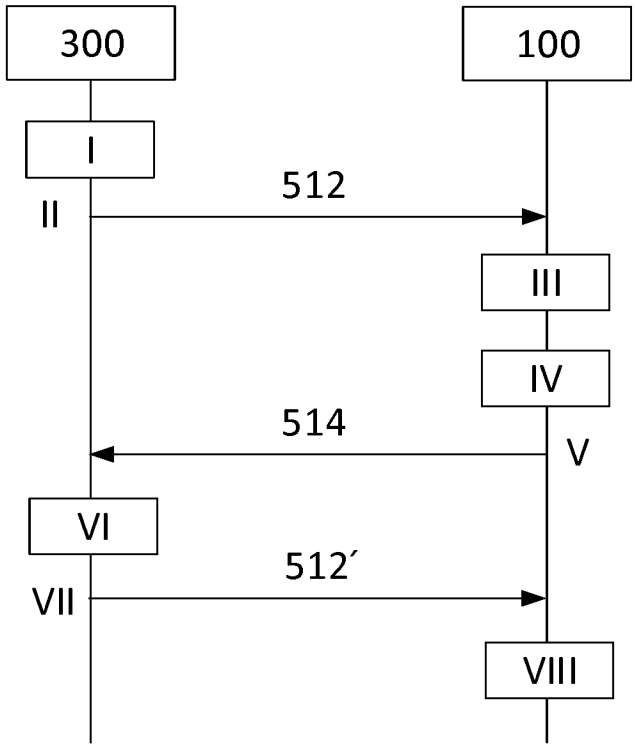

300
100
I
512
II
III
IV
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V
VI
512´
VII
VIII

Fig. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/055711

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W52/02 H04W36/00
ADD. H04W24/10 H04W72/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/126196 A1 (LU QIANXI [CN] ET AL) 7 May 2015 (2015-05-07)	1,2,5-15
Y	figures 4, 6 paragraph [0034] paragraph [0049] - paragraph [0052] paragraph [0055] - paragraph [0066] paragraph [0081] - paragraph [0082] paragraph [0075] paragraph [0096]	3,4

X	GB 2 500 260 A (RENESAS MOBILE CORP [JP]) 18 September 2013 (2013-09-18)	1,2,6,7, 10,13-15
A	figures 6, 7 page 15, line 14 - line 22 page 6, line 5 - line 10 page 11, line 11 - line 22	3-5,8,9

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 October 2018	06/11/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Tavares, José

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/055711

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/285169 A1 (YANG WEIDONG [US] ET AL) 19 November 2009 (2009-11-19) paragraph [0020]	3
Y	US 2015/271755 A1 (KARRI SAI SRAVAN BHARADWAJ [US] ET AL) 24 September 2015 (2015-09-24) paragraph [0060]	4

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/055711

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015126196 A1	07-05-2015	EP 2832177 A1	04-02-2015
		US 2015126196 A1	07-05-2015
		WO 2013147665 A1	03-10-2013
GB 2500260 A	18-09-2013	NONE	
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		WO 2009140082 A1	19-11-2009
US 2015271755 A1	24-09-2015	NONE	