[0102]
This is illustrated in Fig. 16, which shows a power-limited situation where two uplink transmissions are scheduled for the UE, one to the MeNB and one to the SeNB. As apparent therefrom, the simultaneous uplink transmissions exceed to the total maximum UE transmit power, for which reasons power scaling is performed by the UE for the uplink transmissions so as to keep the total power used for the two transmissions below the total maximum UE transmit power. Power scaling in turn reduces the scheduling efficiency and performance.

Citation List

Non Patent Literature
[0103]
NPL 1 : 3GPP TS 36.211, "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation", version 8.9.0
NPL 2 : 3GPP TS 36.321, "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification", version 10.0.0
NPL 3 : 3GPP TS 36.213, "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures", version 8.8.0
NPL 4 : 3GPP TS 36.133, "Requirements for support of radio resource management", version 8.7.0
NPL 5 : 3GPP TS 36.101, "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception", version 8.7.0

Summary
[0104]
One non-limiting and exemplary embodiment provides an improved method for power control in a mobile communication system with a mobile station in dual connectivity with a master and secondary base station, avoiding the problems of the prior art as identified above. Another exemplary embodiment provides the power headroom reporting so as to assist in the improved power control for dual connectivity scenarios.
[0105]
Additional benefits and advantages of the disclosed embodiments will be apparent from the specification and Figures. The benefits and/or advantages may be individually provided by the various embodiments and features of the specification and drawings disclosure, and need not all be provided in order to obtain one or more of the same.
[0106]
According to an aspect, there is provided a mobile station for power headroom reporting in a mobile communication system including: circuitry, which, in operation, establishes a dual connectivity between the mobile station and both a master base station via a first radio link and a secondary base station via a secondary radio link, and generates a power headroom report including a first power headroom report for the first radio link, using a first Media Access Control (MAC) entity which handles MAC functionalities and protocol towards the master base station, calculates a virtual power headroom report for an activated serving cell of the secondary radio link based on a virtual uplink resource assignment for the secondary radio link, when a virtual power headroom calculation is configured; and a transmitter, which, in operation, transmits the power headroom report including at least the first power headroom report from the mobile station to the master base station, wherein, when the virtual power headroom calculation is configured, the power headroom report always additionally includes the virtual power headroom report for the secondary radio link every time a power headroom reporting for the first radio link is triggered.

[0106a]
In one general aspect, the techniques disclosed here feature a method for power headroom reporting in a mobile communication system, wherein a mobile station is connected via a first radio link to a master base station and at least to one secondary base station via a secondary radio link, the method comprising the steps of: calculating by the mobile station a first power headroom report for the first radio link between the mobile station and the master base station, transmitting the calculated first power headroom report together with information allowing the master base station to determine information on the pathloss of the secondary radio link between the mobile station and the secondary base station, from the mobile station to the master base station, and calculating by the mobile station a secondary power headroom report for the secondary radio link between the mobile station and the secondary base station, and transmitting the calculated secondary power headroom report from the mobile station to the secondary base station.

[0107]
~~The general aspect~~Embodiments of the above aspect may be implemented using a system, a device, and a computer program, and any combination of systems, devices, and computer programs.

Brief Description of Drawings
[0108]
[fig. 1] Fig. 1 shows an exemplary architecture of a 3GPP LTE system.
[fig. 2] Fig. 2 shows an exemplary overview of the overall E-UTRAN architecture of 3GPP LTE.
[fig. 3] Fig. 3 shows exemplary subframe boundaries on a downlink component carrier as defined for 3GPP LTE (Release 8/9).
[fig. 4] Fig. 4 shows an exemplary downlink resource grid of a downlink slot as defined for 3GPP LTE (Release 8/9).
[fig. 5] Fig. 5 shows the 3GPP LTE-A (Release 10) Layer 2 structure with activated carrier aggregation for the downlink.
[fig. 6] Fig. 6 shows the 3GPP LTE-A (Release 10) Layer 2 structure with activated carrier aggregation for the uplink.
[fig. 7] Fig. 7 illustrates a DRX operation of a mobile terminal and in particular the DRX opportunity, on-duration, according to the short and long DRX cycle.
[fig. 8] Fig. 8 shows a Power Headroom Report, PHR, MAC control element as defined in 3GPP LTE (Release 8/9).
[fig. 9] Fig. 9 illustrates an extended Power Headroom Report, ePHR, MAC control element as defined in 3GPP LTE (Release 10).
[fig. 10] Fig. 10 illustrates a deployment scenario for small cell enhancement, where macro and small cells are on the same carrier frequency.
[fig. 11] Fig. 11 illustrates further deployment scenarios for small cell enhancement where macro and small cells are on different carrier frequencies, the small cell being outdoor.
[fig. 12] Fig. 12 illustrates further deployment scenarios for small cell enhancement where macro and small cells are on different carrier frequencies, the small cell being indoor.
[fig. 13] Fig. 13 illustrates a further deployment scenario for small cell enhancement with only small cells.
[fig. 14] Fig. 14 gives an overview of the communication system architecture for dual connectivity with macro and small eNBs connected to the core network, where the

CLAIMS:

1. A mobile station for power headroom reporting in a mobile communication system comprising:

circuitry, which, in operation,

establishes a dual connectivity between the mobile station and both a master base station via a first radio link and a secondary base station via a secondary radio link, and

calculates a virtual power headroom report for an activated serving cell of the secondary radio link based on a virtual uplink resource assignment for the secondary radio link, when a virtual power headroom calculation is configured; and

a transmitter, which, in operation, transmits the calculated virtual power headroom report for the secondary radio link from the mobile station to the master base station.

2. The mobile station according to claim 1, wherein the transmitter, in operation, transmits a power headroom report for the first radio link with the calculated virtual power headroom report in a single MAC Control Element.

3. The mobile station according to claim 1, wherein the circuitry, in operation, executes a first MAC entity and a secondary MAC entity, wherein the virtual power headroom report calculation for the secondary radio link is performed in the secondary MAC entity.

4. The mobile station according to one of claim 1, wherein the transmitter, in operation, transmits the calculated virtual power headroom report for the secondary radio link with a power headroom report for the first radio link every time a power headroom reporting for the first radio link is triggered.

5. A master base station for receiving power headroom reporting in a mobile communication system comprising:

circuitry, which, in operation, establishes a dual connectivity between the master base station and a mobile station via a first radio link, wherein the mobile station is additionally connected to a secondary base station via a secondary radio link; and

a receiver, which, in operation, receives a virtual power headroom report for the secondary radio link from the mobile station, wherein the virtual power headroom

~~report is calculated by the mobile station based on a virtual uplink resource assignment for the secondary radio link when a virtual power headroom calculation is configured.~~

~~6. The master base station according to claim 5, wherein the receiver, in operation, receives a power headroom report for the first radio link with the calculated virtual power headroom report in a single MAC Control Element.~~

~~7. The master base station according to one of claim 5, wherein the receiver, in operation, receives the calculated virtual power headroom report for the secondary radio link with a power headroom report for the first radio link every time a power headroom reporting for the first radio link is triggered at the mobile station.~~

~~8. A method for power headroom reporting in a mobile communication system comprising:~~

~~establishing a dual connectivity between a mobile station and both a master base station via a first radio link and a secondary base station via a secondary radio link;~~

~~calculating a virtual power headroom report for an activated serving cell of the secondary radio link based on a virtual uplink resource assignment for the secondary radio link, when a virtual power headroom calculation is configured; and~~

~~transmitting the calculated virtual power headroom report for the secondary radio link from the mobile station to the master base station.~~

~~9. The method according to claim 8, wherein a power headroom report for the first radio link is transmitted with the calculated virtual power headroom report in a single MAC Control Element.~~

~~10. The method according to claim 8, wherein the method comprising:~~

~~executing a first MAC entity and a secondary MAC entity, wherein the virtual power headroom report calculation for the secondary radio link is performed in the secondary MAC entity.~~

~~11. The method according to one of claim 8, wherein the calculated virtual power headroom report for the secondary radio link is transmitted with a power headroom report for the first radio link every time a power headroom reporting for the first radio link is triggered.~~

~~12. A method for receiving power headroom reporting in a mobile communication system comprising:~~

~~establishing a dual connectivity between a master base station and a mobile station via a first radio link, wherein the mobile station is additionally connected to a secondary base station via a secondary radio link; and~~

~~receiving a virtual power headroom report for the secondary radio link from the mobile station to the master base station, wherein the virtual power headroom report is calculated by the mobile station based on a virtual uplink resource assignment for the secondary radio link, when a virtual power headroom calculation is configured.~~

~~13. The method according to claim 12, wherein a power headroom report for the first radio link is received with the calculated virtual power headroom report in a single MAC Control Element.~~

~~14. The method according to one of claim 12, wherein the calculated virtual power headroom report for the secondary radio link is received with a power headroom report for the first radio link every time a power headroom reporting for the first radio link is triggered at the mobile station.~~

1. A mobile station for power headroom reporting in a mobile communication system comprising:

circuitry, which, in operation,

establishes a dual connectivity between the mobile station and both a master base station via a first radio link and a secondary base station via a secondary radio link, and

generates a power headroom report including a first power headroom report for the first radio link, using a first Media Access Control (MAC) entity which handles MAC functionalities and protocol towards the master base station,

calculates a virtual power headroom report for an activated serving cell of the secondary radio link based on a virtual uplink resource assignment for the secondary radio link, when a virtual power headroom calculation is configured; and

a transmitter, which, in operation, transmits the power headroom report

including at least the first power headroom report from the mobile station to the master base station, wherein, when the virtual power headroom calculation is configured, the power headroom report always additionally includes the virtual power headroom report for the secondary radio link every time a power headroom reporting for the first radio link is triggered.

2. The mobile station according to claim 1, wherein the transmitter, in operation, transmits the power headroom report including the first power headroom report and the virtual power headroom report in a single MAC Control Element.

3. A method for power headroom reporting in a mobile communication system comprising:

establishing a dual connectivity between a mobile station and both a master base station via a first radio link and a secondary base station via a secondary radio link;

generating, by the mobile station, a power headroom report including a first power headroom report for the first radio link, using a first Media Access Control (MAC) entity which handles MAC functionalities and protocol towards the master base station;

calculating, by the mobile station, a virtual power headroom report for an activated serving cell of the secondary radio link based on a virtual uplink resource assignment for the secondary radio link, when a virtual power headroom calculation is configured; and

transmitting the power headroom report including at least the first power headroom report from the mobile station to the master base station, wherein, when the virtual power headroom calculation is configured, the power secondary radio link every time a power headroom reporting for the first radio link is triggered.

4. The method according to claim 3, wherein the power headroom report including the first power headroom report and the virtual power headroom report is transmitted in a single MAC Control Element.