Certain embodiments of the present invention seek to provide an apparatus that includes relay nodes that uses only uplink (UL) channels as a relay link.

Certain embodiments of the present invention seek to provide bi-directional links and multi hops relay using Downlink (DL)-only, or alternatively uplink (UL) -only, channels, typically by providing a relay having functionality of a plurality of LTE mobile stations (UEs).

Certain embodiments of the present invention seek to provide a way to send uplink (UL) backhaul data using base station functionality of the relay.

Certain embodiments of the present invention seek to enable at least one uplink to be used for downstream communication or at least one downlink to be used for upstream communication by providing an inverse relay e.g. as per Figs. 3, 4 herein and/or a hybrid inverse Relay e.g. as described herein with reference to element 160 in Fig. 16 and/or an inverse relay (iRelay) Proxy including, typically, in software in the management layer, an interface module with relevant functionality.

Disclosed herein is a cellular communication system serving at least one mobile communication device, the system including: at least one backhauling link provided between: a mobile station functionality; and a base station functionality residing in a level below the mobile station functionality.

Disclosed herein is a cellular communication system serving at least one mobile communication device, the system including at least one pair of backhauling links that provides bi-directional communication between relays by utilizing downlink channels only.

Disclosed herein is a cellular communication system serving at least one mobile communication device, the system including at least one pair of backhauling links that provides bi-directional communication between relays by utilizing uplink channels only.

In the above disclosures, the system also comprises at least one additional pair of backhauling links that provides bi-directional communication between relays by utilizing both an uplink channel and a downlink channel.

In the above disclosures, at least one pair of backhauling links provides bi-directional communication between relays in different levels by utilizing downlink channels only.

In the above disclosures, at least one pair of backhauling links provides bi-directional communication between relays in different levels by utilizing uplink channels only.

In the above disclosures, the pair of backhauling links which provides bi-directional communication between relays in different levels does not utilize any uplink channel.

In the above disclosures, the pair of backhauling links which provides bi-directional communication between relays in different levels does not utilize any downlink channel.

In the above disclosures, the mobile communication device, backhauling link, mobile station functionality and base station functionality are all part of an LTE communication network.

In the above disclosures, all downlink channels comprise MBSFN channels.

In the above disclosures, the MBSFN channels of different relays use different sub-

frames.

In the above disclosures, the MBSFN channels of different relays use orthogonal sub-frames.

In the above disclosures, said pair of backhauling links comprises an uplink from a mobile station functionality to a base station functionality residing in a level below the mobile station functionality.

In the above disclosures, said pair of backhauling links comprises a downlink to a mobile station functionality from a base station functionality residing in a level below the mobile station functionality.

In the above disclosures, said cellular communication system comprises an LTE-standard cellular communication system.

In the above disclosures, said cellular communication system comprises a WiMax-standard cellular communication system.

In the above disclosures, said cellular communication system comprises a HSPA-standard cellular communication system.

In the above disclosures, said cellular communication system comprises a WCDMA-standard cellular communication system.

In the above disclosures, said cellular communication system comprises a GSM-standard cellular communication system.

In the above disclosures, said cellular communication system comprises a CDMA - standard cellular communication system.

In the above disclosures, said cellular communication system comprises a WiFi-standard cellular communication system.

In the above disclosures, the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station functionality, and wherein at least one uplink channel is used to enable down-stream data flow.

In the above disclosure, only uplink channels are used to enable down-stream data flow.

In the above disclosures, the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station functionality, and wherein at least one downlink channel is used to enable up-stream data flow.

The above disclosures, implemented by a relay which provides functionality of: a base station; and a plurality of mobile stations.

Disclosed herein is a cellular communication system serving at least one mobile communication device, comprising mobile station functionality operable in idle mode and enabling a backhauling communication link.

In the above disclosure, said backhauling communication link is between relays.

In the above disclosure, said backhauling communication link is provided by receiving

at least one downlink channel.

In the above disclosure, said at least one downlink channel is one of: the following a unicast, broadcast or multicast channel.

Disclosed herein is a cellular communication system having a system core and serving at least one mobile communication device and comprising mobile station functionality, wherein said mobile station functionality includes two communication links, comprising a radio link between said mobile station functionality and base station functionality and a second physical link between said mobile station functionality and said system core.

Disclosed herein is a cellular communication system having a system core and serving at least one mobile communication device, comprising mobile station functionality that is directly connected to said system core.

In the above disclosure, said backhauling communication link is between relay and core.

In the above disclosure, said at least one downlink channel comprises a MBSFN channel.

In the above disclosures, the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station functionality, and wherein only downlink channels are used to enable up-stream data flow.

In the above disclosure, a proxy mobile station comprising at least mobile station functionality is connected directly to the core and is served, via a backhauling link, by base station functionality.

In the above disclosure, said base station functionality resides in a topmost level in said relay level sequence.

In the above disclosure, said relay level sequence includes at least one individual relay level atop the bottom-most level and wherein at least one mobile station functionality residing in the individual relay level is connected, via a backhauling link, to a base station functionality residing in a lower level.

In the above disclosures, said cellular communication system has at least one interface operable according to at least one of the following standards: 2G, CDMA, GSM 3G, WCDMA, HSPA, 4G, WiMAX, LTE, LTE-Advanced, WiFi.

In the above disclosures, said cellular communication system enables multiple backhauling links between a single relay and more than one entity chosen from a set of: relay, mobile station, mobile station functionality, mobile station proxy and base-station.

In the above disclosures, said cellular communication system enables multiple backhauling links between a single entity in a specific layer and more than one entity in higher layers.

In the above disclosure, said single entity has additional backhauling links with more than one entity in lower layers.

Disclosed herein is a cellular communication system serving at least one mobile communication device, the system including: apparatus for providing at least one backhauling link between: a mobile station functionality; and a base station functionality residing in a level below the mobile station functionality.

In the above disclosures, a node that provides mobile station functionality or base station functionality also enables relay functionality operative in accordance with 3GPP TS 36.806.

In the above disclosures, a node that provides mobile station functionality or base station functionality uses both a BCH channel and a MBSFN channel to enable feedback between one node and other node.

In the above disclosures, a node that provides mobile station functionality or base station functionality effects a dynamic allocation of a subframe number and a subframe quantity.

In the above disclosure, said dynamic allocation is devived from at least one mobile station requirements.

Disclosed herein is a system according to any of the preceding embodiments, wherein a node that provides at least one of mobile station functionality and base station functionality uses at least one downlink channel to transmit: at least one up-stream backhauling link; and at least one down-stream backhauling link.

In the above disclosure, said apparatus for providing at least one backhauling link includes an inverse relay, a relay proxy and a mobile-station – core interface module.

A method corresponding to any of the preceding disclosures.

According to a first aspect of the present invention, there is provided a cellular communication system operative in conjunction with a cellular network and serving at least one mobile communication device, the system including: at least one backhauling link provided between: a first relay having a mobile station functionality operatively associated, directly or ultimately, with said at least one mobile communication device served by a core, said mobile station functionality residing in said first relay present at an nth hierarchical level of said cellular network; and a second relay having a base station functionality present at an mth level of the cellular network, which is below the first relay in which said mobile station functionality resides, and hence is further from the core than said first relay, wherein said at least one backhauling link provides bi-directional communication between said first relay and said second relay by utilizing downlink channels only.

In an embodiment of the first aspect, serving said at least one mobile communication device, the system including at least one pair of backhauling links that provides said bi-directional communication between said first relay and said second relay by utilizing said downlink channels only.

In an embodiment of the first aspect, the network has a core, wherein the system also includes said mobile station functionality connected to the core; and wherein said pair of backhauling links includes a backhauling link via which said mobile station functionality

connected directly to the core is served.

In an embodiment of the first aspect, the mobile station functionality is connected to the core through a mobile station-core interface module and is served, via said backhauling link, by base station functionality residing in a topmost level in the hierarchical network.

In an embodiment of the first aspect, said first relay and said second relay comprises a cellular communication network node which includes an antenna, transmitter and receiver.

In an embodiment of the first aspect, said first relay and said second relay each comprise a node in a cellular communication network including base stations, the node including an antenna, transmitter and receiver and functioning both as a mobile communication device and a base station and extending the coverage of the network's base-stations.

In an embodiment of the first aspect, the system also comprises at least one additional pair of backhauling inks that provides bi-directional communication between said first relay and said second relay by utilizing both an uplink channel and a downlink channel.

In an embodiment of the first aspect, at least one pair of backhauling links provides bi-directional communication between said first relay and said second in different levels by utilizing uplink channels only.

An embodiment of the first aspect, implemented by a relay which provides functionality of: a base station; and a plurality of mobile stations.

In an embodiment of the first aspect, all downlink channels comprise MBSFN channels.

In an embodiment of the first aspect, the MBSFN channels of different relays use different sub-frames.

In an embodiment of the first aspect, the MBSFN channels of different relays use orthogonal sub-frames.

In an embodiment of the first aspect, a node that provides mobile station functionality or base station functionality uses both a BCH channel and a MBSFN channel to enable feedback between one node and other node.

In an embodiment of the first aspect, a node that provides mobile station functionality or base station functionality effects a dynamic allocation of a subframe number and a subframe quantity.

In an embodiment of the first aspect, said dynamic allocation is derived from at least one mobile station requirements.

In an embodiment of the first aspect, a node that provides at least one of mobile station functionality and base station functionality uses at least one downlink channel to transmit: at least one up-stream backhauling link; and at least one down-stream backhauling link.

In an embodiment of the first aspect, the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station

functionality, and wherein at least one uplink channel is used to enable down-stream data flow.

In an embodiment of the first aspect, only uplink channels are used to enable down-stream data flow.

In an embodiment of the first aspect, the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station functionality, and wherein at least one downlink channel is used to enable up-stream data flow.

In an embodiment of the first aspect, the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station functionality, and wherein only downlink channels are used to enable up-stream data flow.

In an embodiment of the first aspect, said cellular communication system enables multiple backhauling links between a single entity in a specific layer and more than one entity in higher layers.

According to a second aspect of the present invention, there is provided a cellular communication method useful in conjunction with a cellular network and serving at least one mobile communication device, the method including: providing at least one backhauling link between: a first relay having a mobile station functionality operatively associated, directly or ultimately, with said at least one mobile communication device served by a core, said mobile station functionality residing in said first relay present at an nth hierarchical level of said cellular network; and a second relay having a base station functionality present at an mth level of the cellular network, which is below the first relay in which said mobile station functionality resides, and hence is further from the core than said first relay, wherein the at least one backhauling link provides bi-directional communication between said first relay and said second relay by utilizing downlink channels only.

In an embodiment of the second aspect, said first relay and said second relay for providing the at least one backhauling link includes an inverse relay, a relay proxy and a mobile-station-core interface module.

In an embodiment of the second aspect, the relay proxy is configured to decapsulate and encapsulate backhauling control and user data that arrives from to the core.

In an embodiment of the second aspect, the relay proxy is configured to decapsulate and encapsulate backhauling control and user data that is sent to the core.

In an embodiment of the second aspect, cellular communication method for serving said at least one mobile communication device, the method including providing at least one pair of backhauling links that provide bi-directional communication between said first relay and said second relay by utilizing downlink channels only.

In an embodiment of the second aspect, said first relay and said second relay functions both as a mobile communication device and a base station, extending coverage of base-

stations.

According to a third aspect of the present invention, there is provided a computer program product comprising a computer readable non-transitory medium having computer readable program code for performing a cellular communication method for serving at least one mobile communication device, the method including: providing at least one backhauling link between: a first relay having a mobile station functionality operatively associated, directly or ultimately, with at least one mobile communication device served by a core, said mobile station functionality residing in first relay present at an nth hierarchical level of said cellular network; and a second relay having a base station functionality present at an mth level of the cellular network, which is below the first relay in which said mobile station functionality resides, and hence is further from the core than said first relay, wherein the at least one backhauling link provides bi-directional communication between said first relay and said second relay by utilizing downlink channels only.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Prior art Fig. 1 is an example of prior art L3 relay as depicted in 3GPP TR 36.806;

Fig. 2 is an example of relay apparatus that uses an LTE base station (eNB) in order to send backhaul data;

Fig. 3 is example architecture of inverse-relay apparatus that uses only Downlink (DL) channels as a relay link;

Fig. 4 is example architecture of inverse-relay apparatus that uses only uplink (UL) channels as a relay link;

Fig. 5 is an example of aggregated relayed uplink (UL) data that flows from two different mobile stations to the core using an LTE base station (eNB) as a backhauling device. in Fig. 5, upstream data is transmitted over only a backhauling uplink e.g. employing the architecture of Fig. 4.

Fig. 6 is an example of aggregated Downlink (DL) relayed data that flows from

CLAIMS

1. A cellular communication system operative in conjunction with a cellular network and serving at least one mobile communication device, the system comprising:

at least one backhauling link provided between:

a first relay having a mobile station functionality operatively associated, directly or ultimately, with said at least one mobile communication device served by a core, said mobile station functionality residing in said first relay present at an nth hierarchical level of said cellular network; and

a second relay having a base station functionality present at an mth level of the cellular network, which is below the first relay in which said mobile station functionality resides, and hence is further from the core than said first relay,

wherein said at least one backhauling link provides bi-directional communication between said first relay and said second relay by utilizing downlink channels only.

2. A system according to claim 1 serving said at least one mobile communication device, the system including at least one pair of backhauling links that provides said bi-directional communication between said first relay and said second relay by utilizing said downlink channels only.

3. A system according to claim 2, wherein the network has a core, wherein the system also includes said mobile station functionality connected to the core; and wherein said pair of backhauling links includes a backhauling link via which said mobile station functionality connected directly to the core is served.

4. A cellular communication system according to claim 3, wherein the mobile station functionality is connected to the core through a mobile station-core interface module and is served, via said backhauling link, by base station functionality residing in a topmost level in the hierarchical network.

5. A system according to claim 2, wherein said first relay and said second relay comprises a cellular communication network node which includes an antenna, transmitter and receiver.

6. A system according to claim 2, wherein said first relay and said second relay each comprise a node in a cellular communication network including base stations, the node including an antenna, transmitter and receiver and functioning both as a mobile communication device and a base station and extending the coverage of the network's base-stations.

7. A system according to claim 1, wherein the system also comprises at least one additional pair of backhauling inks that provides bi-directional communication between said first relay and said second relay by utilizing both an uplink channel and a downlink channel.

8. A system according to claim 1, wherein at least one pair of backhauling links provides bi-directional communication between said first relay and said second in different levels by utilizing uplink channels only.

9. A system according to claim 8, implemented by a relay which provides functionality of:
a base station; and
a plurality of mobile stations.

10. A system according to claim 1, wherein all downlink channels comprise MBSFN channels.

11. A system according to claim 10, wherein the MBSFN channels of different relays use different sub-frames.

12. A system according to claim 11, wherein the MBSFN channels of different relays use orthogonal sub-frames.

13. A system according to claim 1, wherein a node that provides mobile station functionality or base station functionality uses both a BCH channel and a MBSFN channel to enable feedback between one node and other node.

14. A system according to claim 1, wherein a node that provides mobile station functionality or base station functionality effects a dynamic allocation of a subframe number and a subframe quantity.

15. A system according to claim 14, wherein said dynamic allocation is derived from at least one mobile station requirements.

16. A system according to claim 1, wherein a node that provides at least one of mobile station functionality and base station functionality uses at least one downlink channel to transmit:

at least one up-stream backhauling link; and

at least one down-stream backhauling link.

17. A system according to claim 1, wherein the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station functionality, and wherein at least one uplink channel is used to enable down-stream data flow.

18. A system according to claim 17, wherein only uplink channels are used to enable down-stream data flow.

19. A system according to claim 1, wherein the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station functionality, and wherein at least one downlink channel is used to enable up-stream data flow.

20. A system according to claim 1, wherein the system also comprises at least one core and a relay level sequence including at least one relay level, each relay level in the sequence including at least one relay having base station functionality and co-located mobile station functionality, and wherein only downlink channels are used to enable up-stream data flow.

21. A system according to claim 1, wherein said cellular communication system enables multiple backhauling links between a single entity in a specific layer and more than one entity in higher layers.

22. A cellular communication method useful in conjunction with a cellular network and serving at least one mobile communication device, the method comprising:

providing at least one backhauling link between:

a first relay having a mobile station functionality operatively associated, directly or ultimately, with said at least one mobile communication device served by a core, said mobile station functionality residing in said first relay present at an nth hierarchical level of said cellular network; and

a second relay having a base station functionality present at an mth level of the cellular network, which is below the first relay in which said mobile station functionality resides, and hence is further from the core than said first relay,

wherein the at least one backhauling link provides bi-directional communication between said first relay and said second relay by utilizing downlink channels only.

23. A method according to claim 22, wherein said first relay and said second relay for providing the at least one backhauling link includes an inverse relay, a relay proxy and a mobile-station-core interface module.

24. A cellular communication method according to claim 23, wherein the relay proxy is configured to decapsulate and encapsulate backhauling control and user data that arrives from to the core.

25. A cellular communication method according to claim 23, wherein the relay proxy is configured to decapsulate and encapsulate backhauling control and user data that is sent to the core.

26. A cellular communication method for serving said at least one mobile communication device according to claim 22, the method including providing at least one pair of backhauling

links that provide bi-directional communication between said first relay and said second relay by utilizing downlink channels only.

27. A method according to claim 26, wherein said first relay and said second relay functions both as a mobile communication device and a base station, extending coverage of base-stations.

28. A computer program product comprising a computer readable non-transitory medium having computer readable program code for performing a cellular communication method for serving at least one mobile communication device, the method comprising:

providing at least one backhauling link between:

a first relay having a mobile station functionality operatively associated, directly or ultimately, with at least one mobile communication device served by a core, said mobile station functionality residing in first relay present at an nth hierarchical level of said cellular network; and

a second relay having a base station functionality present at an mth level of the cellular network, which is below the first relay in which said mobile station functionality resides, and hence is further from the core than said first relay,

wherein the at least one backhauling link provides bi-directional communication between said first relay and said second relay by utilizing downlink channels only.