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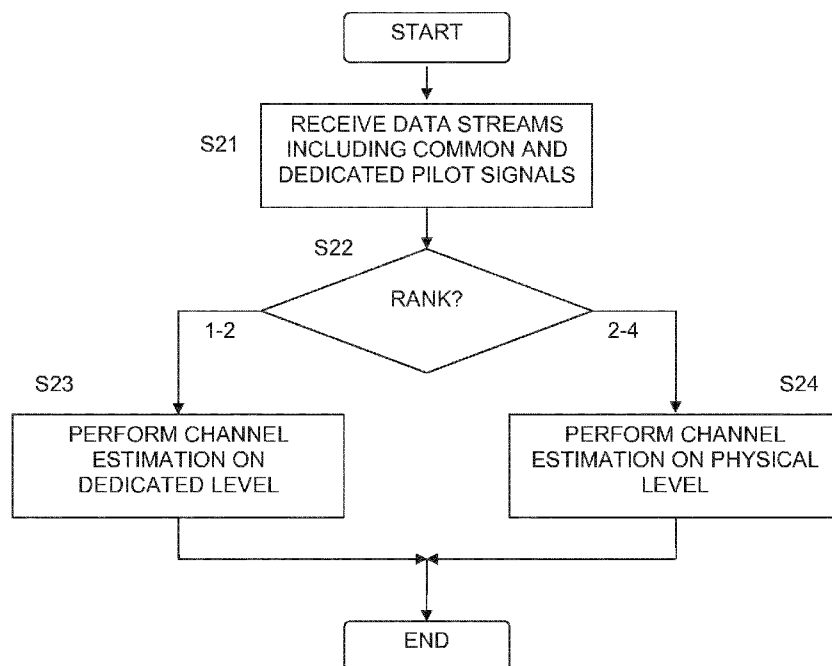


Fig. 4

(57) Abstract: An apparatus and a method are provided by which a plurality of data streams are transmitted and at least one common pilot signal and at least one dedicated pilot signal are transmitted with the plurality of data streams, wherein the number of dedicated pilot signals is set depending on the number of data streams. Moreover, an apparatus and a method are provided by which a plurality of data streams is received, wherein the data streams comprise at least one common pilot signal and at least one dedicated pilot signal, and channel estimation is performed based on the at least one common pilot signal and the at least one dedicated pilot signal.

DESCRIPTION

TITLE

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Enhanced precoded pilot scheme for 4Tx MIMO

Field of the Invention

10 The present invention relates to apparatuses, methods and a computer program product for realizing an enhanced precoded pilot scheme, in particular for 4TX MIMO.

Related background Art

15 The following meanings for the abbreviations used in this specification apply:

	3GPP	Third Generation Partnership Project
	CPICH	Common Pilot Channel
	CIR	Channel Impulse Response
20	CQI	Channel Quality Indicator
	DPICH	Dedicated Pilot Channel
	HSDPA	High Speed Downlink Packet Access
	HS-DSCH	High Speed Downlink Shared Channel
	HS-PDSCH	High Speed Physical Downlink Shared Channel
25	MIMO	Multiple Input Multiple Output
	OVSF	Orthogonal Variable Spreading Factor
	P-CPICH	Primary Common Pilot Channel
	PCI	Pre Coding Indicator
	RI	Rank Indicator
30	S-CPICH	Secondary Common Pilot Channel
	SIMO	Single Input Multiple Output
	TX	Transmit
	UE	User Equipment

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Embodiments of the present invention relate to channel estimation. Channel estimation is performed in order to demodulate a received modulated signal. In non-MIMO and 2x2

MIMO (Multiple Input Multiple Output) systems the channel estimation is based on known common pilot signals broadcasted from the base station. For demodulation on the physical level there is one pilot signal required per transmit antenna.

- 5 Currently, different pilot schemes are under discussion in 3GPP for the standardization of 4Tx (4 branch) MIMO in HSDPA. One option is so-called dedicated pilots or precoded pilots (precoded together with data streams). It seems that 3GPP slightly tends towards this solution. However, many aspects of dedicated pilots are still unclear.
- 10 For the above-mentioned 4x4 MIMO transmission, the channel estimation is based on known dedicated pilot signals, one pilot signal per data stream. The demodulation is thus on the dedicated level. The number of data streams (the rank) can go from 1 to 4. The rank does not change the number of transmit antennas. For example, with MIMO rank 1 (single data stream), there would still be 4 transmit antennas. For channel estimation on
- 15 the physical level, one always needs 4 pilots. For channel estimation on the dedicated level, one needs as many dedicated pilots as there are data streams. For example, with rank 3 there would be 3 different dedicated pilot signals needed.

- That is, dedicated pilots are transmitted together with each data stream. For DL 4x4 (4Tx)
- 20 MIMO that means for each spatially multiplexed stream one dedicated pilot is required. Hence the transmission of 4 parallel streams (rank 4 transmission) requires 4 dedicated pilots. Each of those pilots requires a certain amount of power by which the data power has to be reduced.

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Summary of the Invention

Embodiments of the present invention address this situation and aim to reduce overhead and power for transmitting pilot signals.

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- According to a first aspect of the present invention an apparatus is provided which comprises an interface unit configured to provide connection to a network, and a processor configured to transmit a plurality of data streams via the interface unit, to transmit at least one common pilot signal and at least one dedicated pilot signal with the
- 35 plurality of data streams, and to set the number of dedicated pilot signals depending on the number of data streams.

According to further refinements, the first aspect may be modified as follows:

- The processor may be configured to determine the number of dedicated pilot signals such that, when the number of data streams is higher than one, the sum of the number of common pilot signals and the number of dedicated pilot signals is equal to the number of common transmission channels.

- The processor may be configured to determine the number of dedicated pilot signals such that, when the number of data streams is two to four, the number of common pilot signals is two and the number of the dedicated pilot signals is two, and/or, when the number of data streams is one, the number of the common pilot signals is two and the number of the dedicated pilot signals is one.

- When the number of data streams is one, the processor may be configured is configured to transmit two dedicated pilot signals on two different common transmission channels.

- The processor may be configured to vary a transmission power of at least one of the dedicated pilot signals, and, optionally, to vary the transmission power of the at least one dedicated pilot signal based on the number of data streams.

According to a second aspect of the present invention an apparatus is provided which comprises an interface unit configured to provide connection to a network, and a processor configured to receive a plurality of data streams via the interface unit, wherein the data streams comprise at least one common pilot signal and at least one dedicated pilot signal, and to perform channel estimation based on the at least one common pilot signal and the at least one dedicated pilot signal.

According to further refinements, the second aspect may be modified as follows:

- The processor may be configured to select whether to perform the channel estimation on a physical level or on a dedicated level based on the number of the data streams.

- The processor may be configured to perform the channel estimation on a physical level in case sum of the number of the data streams and the number of the common pilot signals is higher than the number of common transmission channels, and/or to perform the channel estimation on a physical level or on a dedicated level in case sum of the number of the data streams and the number of the common pilot signals is equal to the number of common transmission channels.

- The number of common transmission channels may be four and the number of

common pilot signals may be two, and the processor may be configured to perform channel estimation on a physical level in case the number of data streams is three or four by using the two common pilot signals and two dedicated pilot signals.

- In case the number of data streams is one, the processor may be configured to perform the channel estimation on a dedicated level based on one dedicated pilot signal or to perform the channel estimation based on two dedicated pilot signals on two different common transmission channels.

- The processor may be configured to perform channel estimation on the physical level by using a channel impulse response synthesis for the common pilot signals and the dedicated pilot signals.

According to a third aspect of the present invention a method is provided which comprises transmitting a plurality of data streams, and

transmitting at least one common pilot signal and at least one dedicated pilot signal with the plurality of data streams,

setting the number of dedicated pilot signals depending on the number of data streams.

According to further refinements, the third aspect may be modified as follows:

- The method may further comprise determining the number of dedicated pilot signals such that, when the number of data streams is higher than one, the sum of the number of common pilot signals and the number of dedicated pilot signals is equal to the number of common transmission channels.

- The method may further comprise determining the number of dedicated pilot signals such that, when the number of data streams is two to four, the number of common pilot signals is two and the number of the dedicated pilot signals is two, and/or, when the number of data streams is one, the number of the common pilot signals is two and the number of the dedicated pilot signals is one.

- The method may further comprise, when the number of data streams is one, transmitting two dedicated pilot signals on two different common transmission channels.

- The method may further comprise varying a transmission power of at least one of the dedicated pilot signals, wherein, optionally, the transmission power of the at least one dedicated pilot signal may be varied based on the number of data streams.

According to a fourth aspect of the present invention a method is provided which comprises

receiving a plurality of data streams, wherein the data streams comprise pilot signals, the pilot signals comprising at least one common pilot signal and at least one dedicated pilot signal, and

- 5 performing channel estimation based on the at least one common pilot signal and the at least one dedicated pilot signal.

According to further refinements, the fourth aspect may be modified as follows:

- 10 - The method may further comprise selecting whether to perform the channel estimation on a physical level or on a dedicated level based on the number of the data streams.
- The method may further comprise performing the channel estimation on a physical level in case sum of the number of the data streams and the number of the common pilot signals is higher than the number of common transmission channels, and/or performing the channel estimation on a physical level or on a dedicated level in
15 case sum of the number of the data streams and the number of the common pilot signals is equal to the number of common transmission channels.
- The number of common transmission channels may be four and the number of common pilot signals may be two, and the channel estimation may be performed on a physical level in case the number of data streams is three or four by using the two
20 common pilot signals and two dedicated pilot signals.
- The method may further comprise performing the channel estimation on a dedicated level based on one dedicated pilot signal, or performing the channel estimation based on two dedicated pilot signals on two different common transmission channels.
- The method may further comprise performing channel estimation on the physical
25 level by using a channel impulse response synthesis for the common pilot signals and the dedicated pilot signals.

According to a fifth aspect of the present invention, a computer program product is provided which comprises code means for performing a method according to the third or
30 fourth aspect or their modifications when run on a processing means or module.

Optionally, the computer program product may be embodied on a computer-readable medium.

35 Thus, according to embodiments of the present invention, the number of dedicated pilot signals, which have to be provided in each data stream, can be reduced. Using less pilots

reduces the overhead and allows for an increased power allocation to the data channel and consequently increases the performance.

Brief Description of the Drawings

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These and other objects, features, details and advantages will become more fully apparent from the following detailed description of embodiments of the present invention which is to be taken in conjunction with the appended drawings, in which:

10 Fig. 1 shows a basic structure of a base station according to an embodiment of the present invention,

Fig. 2 shows a basic operation of a base station according to an embodiment of the present invention,

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Fig. 3 shows a basic structure of a UE according to an embodiment of the present invention,

20 Fig. 4 shows a basic operation of a UE according to an embodiment of the present invention,

Fig. 5 illustrates a prior art solution with respect to an example for rank 4, and

25 Fig. 6 illustrates a solution according to an embodiment of the present invention with respect to an example for rank 4.

Detailed Description of embodiments

30 In the following, description will be made to embodiments of the present invention. It is to be understood, however, that the description is given by way of example only, and that the described embodiments are by no means to be understood as limiting the present invention thereto.

35 However, before explaining some embodiments of the present invention, the following considerations with respect to the solutions according to the prior art are given.

For 4Tx MIMO, it is considered to use 2 different types of pilots, namely:

1. Pilots for channel sounding which have to be continuously transmitted to enable a reliable and permanent feedback of CQI/PCI/RI. Those pilots are: P-CPICH, S-CPICH and relatively low power common pilots on 3rd and 4th antenna. These pilots are examples for a common pilot signal, which is one pilot signal for all users.

2. Pilots for decoding which are just required by the UE receiving data e.g. dedicated pilots. These pilots are examples for a dedicated pilot signal, which is one pilot signal for each user.

In this way, the impact on legacy UEs can be minimized. If a no 4Tx MIMO UE is scheduled the high power demodulation pilots are not needed and don't generate interference.

Embodiments of the present invention just relates to demodulation pilots. Fig: 5 illustrates the currently discussed solution which uses dedicated pilots, as one solution for demodulation pilots. Fig. 5 shows an example for rank 4 (i.e., four data streams), wherein for simplicity 3rd & 4th common pilots are not included in the figure.

The idea for this solution is to send the pilots together with the data stream. In this way, the number of pilots scales with the data rate. For rank 4 transmission four dedicated pilots are transmitted and the channel estimation for demodulation can be done only by this four pilots.

For legacy reasons, the primary and secondary CPICH have to keep their high power.

In the following, some general embodiments according to the present invention are described by referring to Figs. 1 to 4.

Fig. 1 shows a base station 1 as an example for an apparatus according to a more general embodiment of the present invention. The apparatus may be a base station or may be only a part thereof, for example. The base station 1 comprises a processor 11 and an interface unit 12. The interface unit 12 is configured to provide connection to a network, and the processor 11 is configured to transmit a plurality of data streams via the interface

unit, to transmit at least one common pilot signal and at least one dedicated pilot signal with the plurality of data streams, and to set the number of dedicated pilot signals depending on the number of data streams.

- 5 Optionally, the base station 1 may also comprise a memory 13 for storing data and programs, by means of which the processor 11 may carry out its corresponding functions. The interface unit 12 may provide a connection to transmit antennas (not shown), or may itself include transmit antennas. For example, four antennas may be provided in order to realize 4TX MIMO. The transmit antennas are examples for providing common
10 transmission channels, so that in the example of 4TX MIMO, four common transmission channels are provided (i.e., each common transmission channel corresponds to one transmit antenna).

Fig. 2 illustrates a basic operation as carried out by the base station 1 of Fig. 1, for
15 example. In particular, a plurality of data streams is transmitted, and at least one common pilot signal and at least one dedicated pilot signal are transmitted with the plurality of data streams. The number of dedicated pilot signals is set depending on the number of data streams. An example for setting the number of dedicated pilot signal is shown in steps S11 to S13. In step S11, it is checked whether the rank (as an example for the number of
20 data streams) is 1 or 2 to 4. If it is 1, then the number of dedicated pilot signal is set to one in step S12, if the rank is 2 to 4, then the number of dedicated pilot signals is set to two. In step S14, the data streams including the common and dedicated pilot signals are sent.

Fig. 3 shows a user equipment (UE) 2 as an example for another apparatus according to a
25 more general embodiment of the present invention. The apparatus may be a UE or may be only a part thereof, for example. The UE 2 comprises a processor 21 and an interface unit 22. The interface unit 22 is configured to provide connection to a network, and the processor 21 is configured to receive a plurality of data streams via the interface unit 22, wherein the data streams comprise at least one common pilot signal and at least one
30 dedicated pilot signal, and to perform channel estimation based on the at least one common pilot signal and the at least one dedicated pilot signal.

Similar as in case of the base station 1 shown in Fig. 1, optionally, the UE 2 may also comprise a memory 13 for storing data and programs, by means of which the processor
35 21 may carry out its corresponding functions. The interface unit 22 may provide a connection to antennas (not shown), or may itself include antennas.

Fig. 4 illustrates a basic operation as carried out by the UE 2 of Fig. 3, for example. In particular, a plurality of data streams is received in step S21, wherein the data streams comprise at least one common pilot signal and at least one dedicated pilot signal, and a channel estimation is performed based on the at least one common pilot signal and the at least one dedicated pilot signal. The channel estimation can be performed on a dedicated level or a physical level.

Steps S22 to S24 illustrate an example how it can be decided based on the rank whether to perform channel estimation on the dedicated level or the physical level. In step S22, the rank is checked. In case the rank is 1 to 2, the channel estimation is performed on the dedicated level in step S23. In case the rank is 2 to 4, the channel estimation is performed on the physical level. That is, in case the rank is 2, both kinds of channel estimation are possible, so that it can be decided based on other criteria which kind of channel estimation (on the physical level or on the dedicated level) is to be performed. For example, such a decision could be based on the complexity of the kind of channel estimation, or could simply be pre-configured in the network configuration or configuration of the UE.

It is noted that the examples shown in Figs. 2 and 4 relate to an example in which a transmission via four antennas (i.e., four common transmission channels) is performed. However, the invention is not limited to these number examples. Moreover, the data streams may also be referred to as data layers.

Hence, according to certain embodiments of the present invention, the number of dedicated pilot signals (such as DPICH, for example) can be limited, namely by using common pilot signals (such as CPICH) and the dedicated pilot signals in a mixed manner. In particular for a case of rank 3 or 4, in which up to four dedicated pilot signal would have been necessary according to the prior art, a maximum of two dedicated pilot signals are necessary, when two common pilot signals are present anyway.

Thus, according to embodiments of the present invention, the number of used dedicated pilots (DPICH) signals for rank 3 and rank 4 transmissions is reduced. That is, instead of using only dedicated pilots for the channel estimation, the high power common pilots (P/S-CPICH) can be included and the maximum number of pilots can be reduced.

The UE can estimate the channel on a precoded level, i.e. including the precoder or on a physical level on which the common pilots are transmitted. The UE needs in any case as many pilots as it estimates channels. That means for the estimation of common transmission channels 4 different pilots are required. For the estimation of the precoded channels as many pilots are needed as streams are transmitted since the channel has to be estimated for each stream.

The new method dynamically switches between the two kinds of channel estimations depending on the rank of the transmission:

- If rank 1 is used the UE has to estimate the channel on the precoded data stream (layer) since there are not enough pilots for estimating all 4 common transmission channels.

- If rank 2 transmission is used (2 streams) the UE can choose which kind of channel estimation to use since 4 pilots are available, 2 on the physical level and 2 on the dedicated level.

- For rank 3 and 4, the physical level is used for channel estimation since this requires only two dedicated pilots as for rank 2. 1 or 2 dedicated pilots can be saved compared the solution currently discussed in 3GPP where 3 or 4 dedicated pilots are used for rank 3 and 4, respectively. It is noted that the channel estimation on the physical level may be performed with channel impulse response synthesis for antenna 3 and 4 (antenna 1 and 2 CIRs are estimated by P/S-CPICH).

The following table summarizes the proposed options:

Rank	# common pilots (physical level)	# dedicated pilots (dedicated level)	Level of channel estimation for demodulation
1	2	1	Dedicated
2	2	2	physical / dedicated
3	2	2	physical
4	2	2	physical

Thus, for rank for rank 3 and 4, 1 or 2 dedicated pilots can be saved. The two (strong enough) common pilots are there anyway.

- 5 The power of the dedicated pilots may be depending on the rank of the transmission and can be defined by the standard or be signalled by higher layers.

10 In the following, an alternative for rank 1 is described. Namely, for rank 1 transmissions the reception and feedback estimation might be further improved with an alternative solution for rank 1. In the above-described approach for rank 1 the limited precoded/dedicated pilot quality could be further improved with channel impulse response synthesis based on primary DPICH, P-CPICH and S-CPICH, if another/second DPICH will be transmitted on one of the spatial streams different than Primary Spatial Stream.

- 15 For sake of power optimisation, the second DPICH in rank 1 transmission should have variable TX power configured by higher layer. The DPICH2 TX power may vary between rank 1 and rank 2, 3, 4 transmissions. The spatial stream precoding for secondary DPICH should be defined by standard or configured by the network.

- 20 Optionally, in all cases, when the channel impulse response synthesis (physical level of channel estimation) is used, 3rd and 4th common pilots could be switched off. Assuming there are 2 dedicated pilots, 2 common pilots and the knowledge about used precoding weights, all the channels (precoded and non-precoded) can be estimated and used both for demodulation and PCI/CQI/RI estimation.

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It is noted that 3rd and 4th antenna common pilots are suggested in 3GPP discussion to be transmitted together with P-CPICH and S-CPICH but with significantly reduced power – efficient enough for CQI/PCI/RI estimation but inefficient for data demodulation (demodulation requires dedicated pilots).

Hence, according to certain embodiments of the present invention, a reduction of up to 2 dedicated pilot signals is achieved, so overhead and up to 2 OVSF codes can be saved.

- 5 In the following, an implementation example according to an embodiment of the present invention is described by referring to Fig. 6. Fig. 6 illustrates the proposed solutions for an example for rank 4. It is noted that for simplicity, 3th and 4th common pilots are not included in the drawing.
- 10 Thus, if rank 1 transmission is used one dedicated pilot (DPICH1) is transmitted together with the data stream. If rank 2-4 is transmitted, 2 dedicated pilots (DPICH 1 and DPICH 2) are transmitted (as shown in Fig. 6).

- In the alternative option described above in connection with rank 1, 2 dedicated pilots are
15 transmitted also in case of rank1 transmission.

It is noted that the embodiments and the present invention in general is not limited to the specific examples given above.

- 20 For example, in the above embodiments, the number examples for the dedicated and common pilot signals were given for the example of transmission with four antennas, i.e., that up to four data streams are possible. The invention is not limited to these number examples. That is, also other numbers are possible, as long as it can be achieved that the sum of the common pilot signals and the number of the dedicated pilot signal is equal to
25 the number of common transmission channels (antennas). In this way, there is a sufficient number of pilot signals for performing channel estimation on a physical level.

- Moreover, also use of the CIR synthesis for physical level of channel estimation is only an example, and other methods for performing channel estimation on a physical level are
30 possible.

- Hence, according to certain embodiments of the present invention, an apparatus and a method are provided by which a plurality of data streams are transmitted and at least one common pilot signal and at least one dedicated pilot signal are transmitted with the
35 plurality of data streams, wherein the number of dedicated pilot signals is set depending on the number of data streams. Moreover, an apparatus and a method are provided by

which a plurality of data streams is received, wherein the data streams comprise at least one common pilot signal and at least one dedicated pilot signal, and channel estimation is performed based on the at least one common pilot signal and the at least one dedicated pilot signal.

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According to a further aspect of the present invention an apparatus is provided which comprises

means for providing connection to a network,

means for transmitting a plurality of data streams,

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means for transmitting at least one common pilot signal and at least one dedicated pilot signal with the plurality of data streams, and

means for setting the number of dedicated pilot signals depending on the number of data streams.

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According to another aspect of the present invention an apparatus is provided which comprises

means for providing connection to a network,

means for receiving a plurality of data streams, wherein the data streams comprise at least one common pilot signal and at least one dedicated pilot signal, and

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means for performing channel estimation based on the at least one common pilot signal and the at least one dedicated pilot signal.

It is to be understood that any of the above modifications can be applied singly or in combination to the respective aspects and/or embodiments to which they refer, unless they are explicitly stated as excluding alternatives.

25

For the purpose of the present invention as described herein above, it should be noted that

- an access technology via which signaling is transferred to and from a network element may be any technology by means of which a network element or sensor node can access another network element or node (e.g. via a base station or generally an access node). Any present or future technology, such as WLAN (Wireless Local Access Network), WiMAX (Worldwide Interoperability for Microwave Access), LTE, LTE-A, Bluetooth, Infrared, and the like may be used; although the above technologies are mostly wireless access technologies, e.g. in different radio spectra, access technology in the sense of the present invention implies also wired technologies, e.g. IP based access technologies like

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cable networks or fixed lines but also circuit switched access technologies; access technologies may be distinguishable in at least two categories or access domains such as packet switched and circuit switched, but the existence of more than two access domains does not impede the invention being applied thereto,

- 5 - usable communication networks, stations and transmission nodes may be or comprise any device, apparatus, unit or means by which a station, entity or other user equipment may connect to and/or utilize services offered by the access network; such services include, among others, data and/or (audio-) visual communication, data download etc.;
- a user equipment or communication network element (station) may be any device,
10 apparatus, unit or means by which a system user or subscriber may experience services from an access network, such as a mobile phone or smart phone, a personal digital assistant PDA, or computer, or a device having a corresponding functionality, such as a modem chipset, a chip, a module etc., which can also be part of a UE or attached as a separate element to a UE, or the like;
- 15 - method steps likely to be implemented as software code portions and being run using a processor at a network element or terminal (as examples of devices, apparatuses and/or modules thereof, or as examples of entities including apparatuses and/or modules therefore), are software code independent and can be specified using any known or future developed programming language as long as the functionality defined by the method
20 steps is preserved;
- generally, any method step is suitable to be implemented as software or by hardware without changing the idea of the invention in terms of the functionality implemented;
- method steps and/or devices, units or means likely to be implemented as hardware
25 components at the above-defined apparatuses, or any module(s) thereof, (e.g., devices carrying out the functions of the apparatuses according to the embodiments as described above, eNode-B etc. as described above) are hardware independent and can be implemented using any known or future developed hardware technology or any hybrids of these, such as MOS (Metal Oxide Semiconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL (Emitter Coupled Logic), TTL
30 (Transistor-Transistor Logic), etc., using for example ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) components, CPLD (Complex Programmable Logic Device) components or DSP (Digital Signal Processor) components;
- devices, units or means (e.g. the above-defined apparatuses, or any one of their
35 respective means) can be implemented as individual devices, units or means, but this

does not exclude that they are implemented in a distributed fashion throughout the system, as long as the functionality of the device, unit or means is preserved;

- an apparatus may be represented by a semiconductor chip, a chipset, or a (hardware) module comprising such chip or chipset; this, however, does not exclude the possibility
5 that a functionality of an apparatus or module, instead of being hardware implemented, be implemented as software in a (software) module such as a computer program or a computer program product comprising executable software code portions for execution/being run on a processor;

- a device may be regarded as an apparatus or as an assembly of more than one
10 apparatus, whether functionally in cooperation with each other or functionally independently of each other but in a same device housing, for example.

It is noted that the embodiments and examples described above are provided for illustrative purposes only and are in no way intended that the present invention is
15 restricted thereto. Rather, it is the intention that all variations and modifications be included which fall within the spirit and scope of the appended claims.

CLAIMS

1. An apparatus comprising
an interface unit configured to provide connection to a network, and
5 a processor configured to
transmit a plurality of data streams via the interface unit,
transmit at least one common pilot signal and at least one dedicated pilot signal
with the plurality of data streams, and
set the number of dedicated pilot signals depending on the number of data
10 streams.
2. The apparatus according to claim 1, wherein
the processor is configured to determine the number of dedicated pilot signals
such that, when the number of data streams is higher than one, the sum of the number of
15 common pilot signals and the number of dedicated pilot signals is equal to the number of
common transmission channels.
3. The apparatus according to claim 1 or 2, wherein
the processor is configured to determine the number of dedicated pilot signals
20 such that
when the number of data streams is two to four, the number of common pilot
signals is two and the number of the dedicated pilot signals is two, and/or,
when the number of data streams is one, the number of the common pilot signals
is two and the number of the dedicated pilot signals is one.
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4. The apparatus according to any one of the claims 1 to 3, wherein, when the
number of data streams is one,
the processor is configured to transmit two dedicated pilot signals on two different
common transmission channels.
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5. The apparatus according to claim any one of the claims 1 to 4, wherein
the processor is configured to vary a transmission power of at least one of the
dedicated pilot signals.
- 35 6. The apparatus according to claim 5, wherein
the processor is configured to vary the transmission power of the at least one

dedicated pilot signal based on the number of data streams.

7. An apparatus comprising
an interface unit configured to provide connection to a network, and
5 a processor configured to
receive a plurality of data streams via the interface unit, wherein the data streams
comprise at least one common pilot signal and at least one dedicated pilot signal, and
perform channel estimation based on the at least one common pilot signal and the
at least one dedicated pilot signal.

8. The apparatus according to claim 7, wherein
the processor is configured to select whether to perform the channel estimation on
a physical level or on a dedicated level based on the number of the data streams.

9. The apparatus according to claim 7 or 8, wherein
the processor is configured to perform
the channel estimation on a physical level in case sum of the number of the data
streams and the number of the common pilot signals is higher than the number of
common transmission channels, and/or
20 to perform the channel estimation on a physical level or on a dedicated level in
case sum of the number of the data streams and the number of the common pilot signals
is equal to the number of common transmission channels.

10. The apparatus according to any one of the claims 7 to 9, wherein the number of
25 common transmission channels is four and the number of common pilot signals is two,
and the processor is configured to perform channel estimation on a physical level in case
the number of data streams is three or four by using the two common pilot signals and two
dedicated pilot signals.

11. The apparatus according to any one of the claims claim 7 to 10, wherein, in case
30 the number of data streams is one,
the processor is configured to
perform the channel estimation on a dedicated level based on one dedicated pilot
signal or
35 perform the channel estimation based on two dedicated pilot signals on two
different common transmission channels.

12. The apparatus according to one of the claims 7 to 11, wherein
the processor is configured to perform channel estimation on the physical level by
using a channel impulse response synthesis for the common pilot signals and the
5 dedicated pilot signals.

13. A method comprising
transmitting a plurality of data streams, and
transmitting at least one common pilot signal and at least one dedicated pilot
10 signal with the plurality of data streams,
setting the number of dedicated pilot signals depending on the number of data
streams.

14. The method according to claim 13, further comprising
15 determining the number of dedicated pilot signals such that, when the number of
data streams is higher than one, the sum of the number of common pilot signals and the
number of dedicated pilot signals is equal to the number of common transmission
channels.

15. The method according to claim 13 or 14, further comprising
determining the number of dedicated pilot signals such that,
when the number of data streams is two to four, the number of common pilot
signals is two and the number of the dedicated pilot signals is two, and/or,
when the number of data streams is one, the number of the common pilot signals
20 is two and the number of the dedicated pilot signals is one.
25

16. The method according to any one of the claims 13 to 15, further comprising, when
the number of data streams is one,
transmitting two dedicated pilot signals on two different common transmission
30 channels.

17. The method according to claim any one of the claims 13 to 16, further comprising
varying a transmission power of at least one of the dedicated pilot signals.

18. The method according to claim 17, wherein
the transmission power of the at least one dedicated pilot signal is varied based on
35

the number of data streams.

19. A method comprising

receiving a plurality of data streams, wherein the data streams comprise pilot signals, the pilot signals comprising at least one common pilot signal and at least one dedicated pilot signal, and

performing channel estimation based on the at least one common pilot signal and the at least one dedicated pilot signal.

20. The method according to claim 19, further comprising

selecting whether to perform the channel estimation on a physical level or on a dedicated level based on the number of the data streams.

21. The method according to claim 19 or 20, further comprising

performing the channel estimation on a physical level in case sum of the number of the data streams and the number of the common pilot signals is higher than the number of common transmission channels, and/or

performing the channel estimation on a physical level or on a dedicated level in case sum of the number of the data streams and the number of the common pilot signals is equal to the number of common transmission channels.

22. The method according to any one of the claims 19 to 21, wherein the number of common transmission channels is four and the number of common pilot signals is two, and the channel estimation is performed on a physical level in case the number of data streams is three or four by using the two common pilot signals and two dedicated pilot signals.

23. The method according to any one of the claims claim 19 to 22, further comprising, in case the number of data streams is one,

performing the channel estimation on a dedicated level based on one dedicated pilot signal, or

performing the channel estimation based on two dedicated pilot signals on two different common transmission channels.

24. The method according to any one of the claims 19 to 23, further comprising

performing channel estimation on the physical level by using a channel impulse

response synthesis for the common pilot signals and the dedicated pilot signals.

25. A computer program product comprising code means for performing a method according to any one of claims 13 to 24 when run on a processing means or module.

5

26. The computer program product according to claim 25, wherein the computer program product is embodied on a computer-readable medium.

10

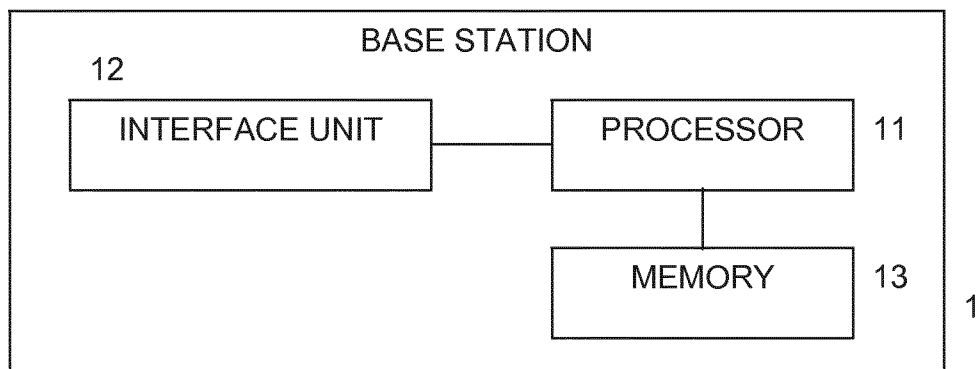


Fig. 1

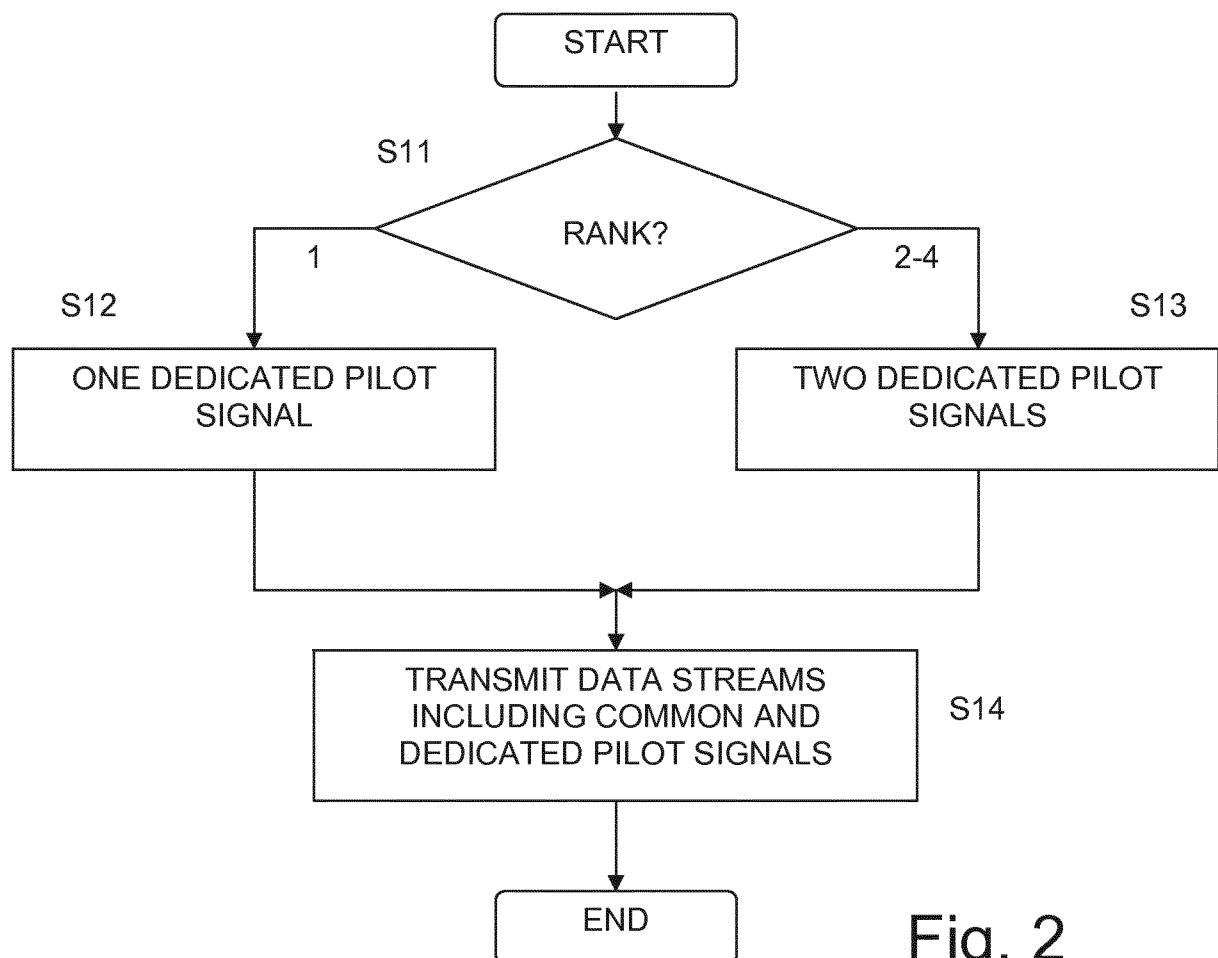


Fig. 2

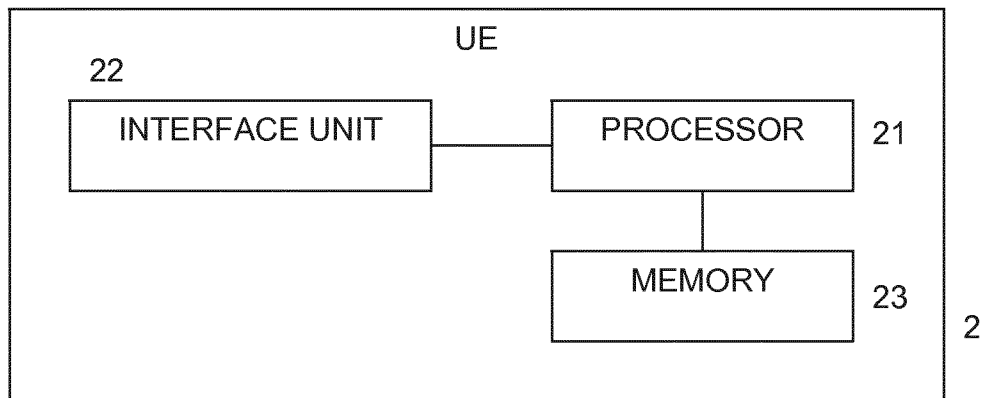


Fig. 3

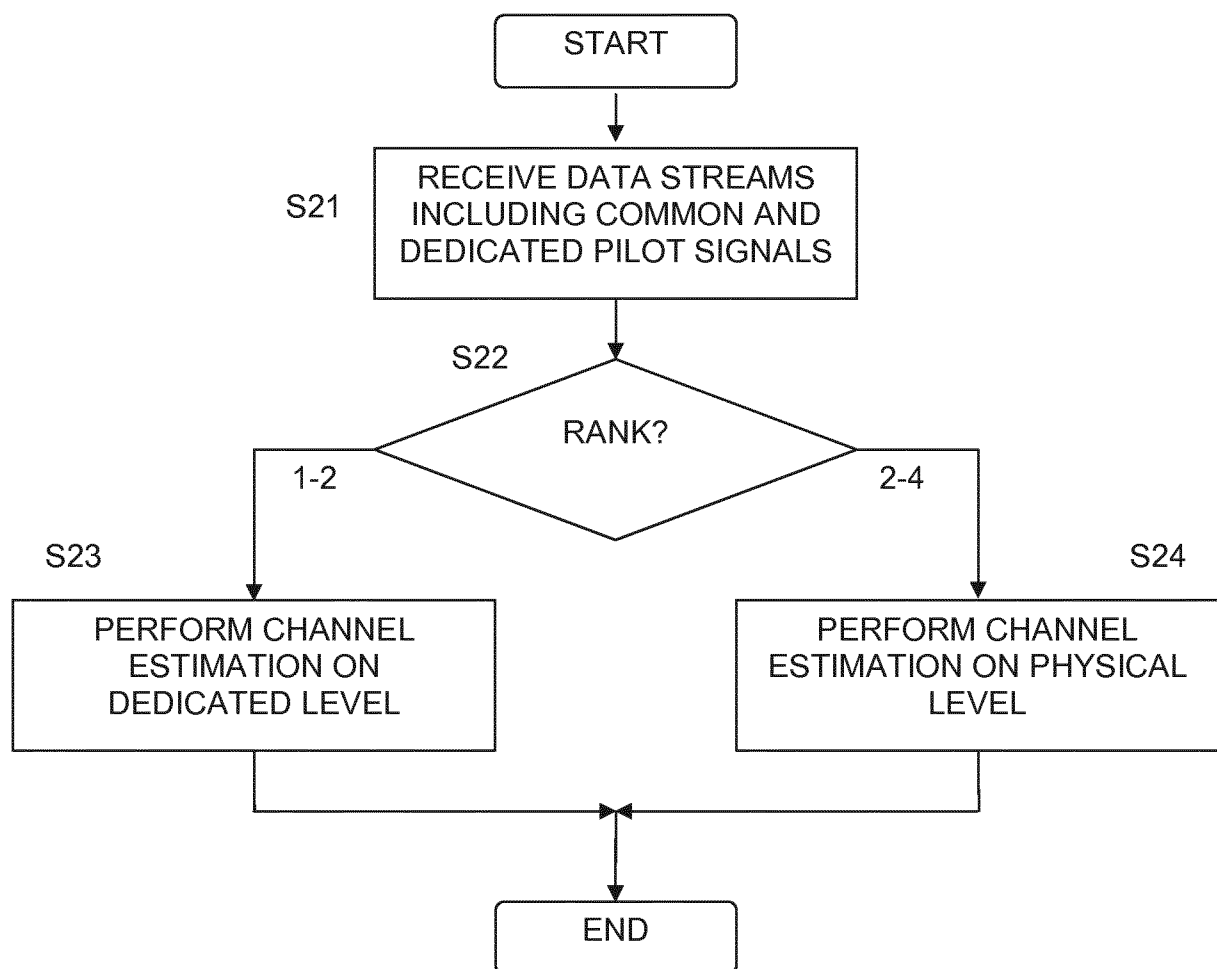


Fig. 4

3/3

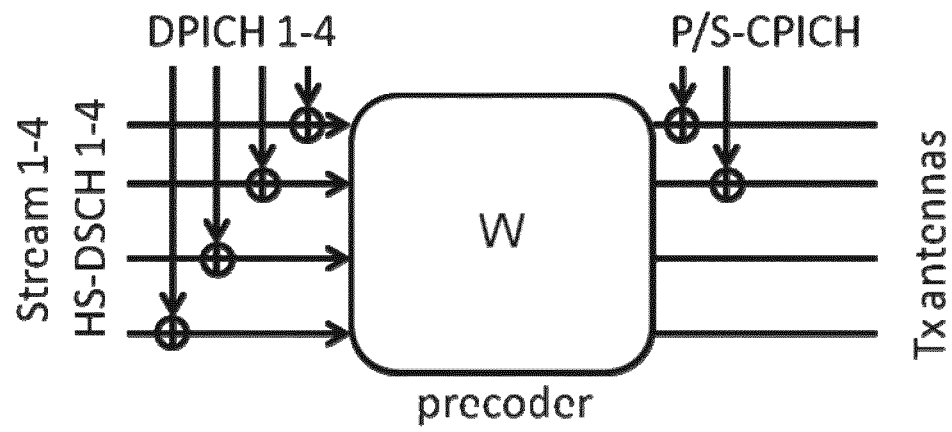


Fig. 5

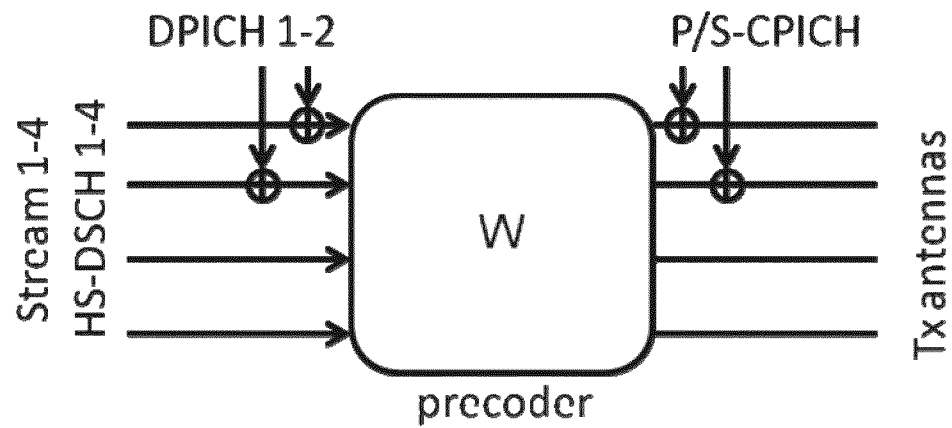


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/059537

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04B7/00 H04L5/00 H04W16/00
ADD.

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)

H04B H04L 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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/017628 A1 (NORTEL NETWORKS LTD [CA]; MA JIANGLEI [CA]; XU HUA [CA]; ZHANG HANG [C] 18 February 2010 (2010-02-18)	1,4-8, 13, 16-20, 25,26
A	page 3, line 2 - line 21 page 6, line 12 - page 7, line 9	2,3, 9-12,14, 15,21-24
A	----- WO 2007/149722 A1 (INTEL CORP [US]; SHI JUN [US]; LI QINGHUA [US]; SUN HONGMEI [CN]; HO M) 27 December 2007 (2007-12-27) page 6, line 3 - line 15	1-26
A	----- US 2005/047529 A1 (LUO TAO [US]) 3 March 2005 (2005-03-03) figure 3 -----	1-26



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

6 August 2013

Date of mailing of the international search report

20/08/2013

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2013/059537

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010017628 A1	18-02-2010	CN 102177665 A EP 2313990 A1 JP 2011530901 A US 2011306291 A1 US 2013012119 A1 WO 2010017628 A1	07-09-2011 27-04-2011 22-12-2011 15-12-2011 10-01-2013 18-02-2010
WO 2007149722 A1	27-12-2007	CN 101473555 A EP 2050204 A1 US 2007293172 A1 WO 2007149722 A1	01-07-2009 22-04-2009 20-12-2007 27-12-2007
US 2005047529 A1	03-03-2005	NONE	