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(54) **Title:** NETWORK ASSISTED INTERFERENCE CANCELLATION AND SUPPRESSION FOR CQI REPORTS IN COMMUNICATION NETWORK

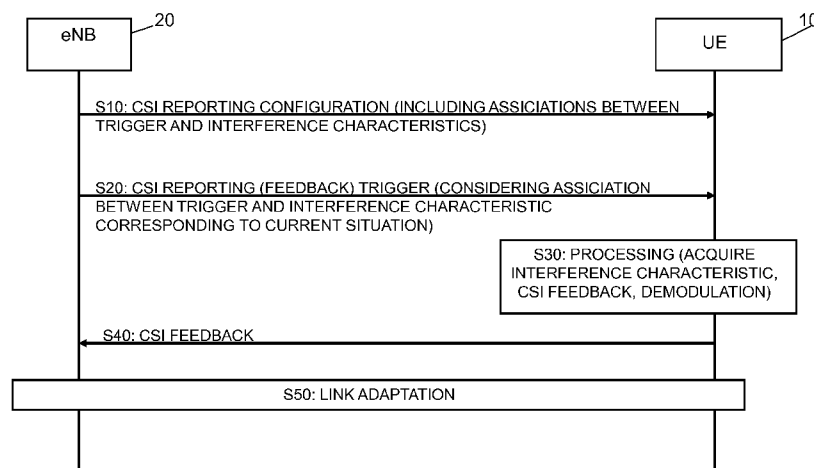


Fig. 2

(57) **Abstract:** A method including providing configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed; and causing transmission of an instruction for a connection state reporting mode according to an interference characteristic in a current communication situation.

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NETWORK ASSISTED INTERFERENCE CANCELLATION AND SUPPRESSION
FOR CQI REPORTS IN COMMUNICATION NETWORK

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DESCRIPTION

BACKGROUND

Field

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The present invention relates to apparatuses, methods, systems, computer programs, computer program products and computer-readable media usable for cancelling and suppressing interference in a communication network.

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Background Art

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The following description of background art may include insights, discoveries, understandings or disclosures, or associations, together with disclosures not known to the relevant prior art, to at least some examples of embodiments of the present invention but provided by the invention. Some of such contributions of the invention may be specifically pointed out below, whereas other of such contributions of the invention will be apparent from the related context.

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

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3GPP	3 rd Generation Partner Project
BS:	base station
CoMP:	coordinated multipoint
CP:	cyclic prefix
CPU:	central processing unit
CQI:	channel quality indicator

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	CRS:	cell specific reference signal
	CSI:	channel state information
	CSI-RS:	channel state information reference signal
	DCI:	downlink control information
5	DL:	downlink
	eNB:	evolved node B
	ePDCCH:	enhanced physical downlink control channel
	IC:	interference cancellation
	ID:	identification, identifier
10	IMR:	interference measurement resource
	IRC:	interference rejection combining
	LTE:	Long Term Evolution
	LTE-A:	LTE Advanced
	MBSFN:	multicast broadcast single frequency network
15	MCS:	modulation and coding scheme
	MIMO:	multiple input multiple output
	MU:	multi user
	NAICS:	network assisted interference cancellation and suppression
	NZP:	non-zero power
20	PA:	power offset value
	PCI:	physical cell ID
	PDCCH:	physical downlink control channel
	PDSCH:	physical downlink shared channel
	PMI:	precoding matrix indicator
25	PUCCH:	physical uplink control channel
	PUSCH:	physical uplink shared channel
	R-ML:	reduced complexity maximum likelihood
	RI:	rank indicator
	RRC:	radio resource control
30	SU:	single user
	SLIC:	symbol level interference cancellation
	TBS:	transport block size
	TDD:	time division duplex
	TM:	transmission mode

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TS: transmission scheme
UE: user equipment
UL: uplink
ULA: uniform linear antenna
5 VCI: virtual cell ID
ZP: zero power

Embodiments of the present invention are related to a communication network in which interference cancellation and interference suppression on
10 the side of a communication element such as a UE is supported by the communication network infrastructure, e.g. by a communication network control element, such as for example a base station or eNB.

SUMMARY

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According to an example of an embodiment, there is provided, for example, a method including providing configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the
20 configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed; and causing transmission of an instruction for a connection state reporting mode according to an interference characteristic in a current communication
25 situation.

Furthermore, according to an example of an embodiment, there is provided, for example, an apparatus including at least one processing circuitry, and at least one memory for storing instructions to be executed by the processing
30 circuitry, wherein the at least one memory and the instructions are configured to, with the at least one processing circuitry, cause the apparatus at least: to provide configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the

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configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed; and to cause transmission of an instruction for a connection state reporting mode according to an interference characteristic in a current communication situation.

According to further refinements, these examples may include one or more of the following features:

- the interference characteristic in the current communication situation may be determined from at least one of an own measurement of parameters related to the interference characteristic and an external signaling conveying parameters related to the interference characteristic; and, as the instruction for a connection state reporting mode which is caused to be transmitted, an instruction for a connection state reporting mode may be selected on the basis of the determined interference characteristic;

- the selecting may further comprise comparing the determined interference characteristic and the interference characteristic to be assumed, which is included in the configuration information associated to the instruction for the connection state reporting mode;

- a connection state feedback may be received in response to the instruction caused to be transmitted, the connection state feedback may be processed, and a link adaptation may be performed on the basis of a result of the processing of the connection state feedback;

- the configuration information may be provided by using a higher layer signaling between the communication element and the communication network;

- the instruction for the connection state reporting mode may include one of a periodic channel state information reporting mode and an aperiodic channel state information reporting mode;

- the at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed may be indicated by a mapping of a specific value of a request field used for instructing the connection state

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reporting mode and a radio resource control signaling indicating a specific characteristic of an interference source or at least one subset of a radio resource control signaling;

5 - the interference characteristic to be assumed may be indicated by parameters related to at least one of a receiver type of a communication in the communication network, a transmission mode used in a communication in the communication network, a transmission scheme used in a communication in the communication network, a resource allocation in a communication in the communication network, a parameter subset
10 including at least one of a codebook subset based on an antenna type, a subset of virtual cell identifications, a subset of physical cell identifications, a subset of power offset values, a subset of reference signals, a subset of interference measurement resources, a subset of precoding matrix indicators, a subset of modulations orders, a subset of time division duplex
15 downlink/uplink configurations, a target number of interferers to be canceled and a subset of a radio resource control signaling;

 - the processing may be implemented in a communication network control element of the communication network, wherein the communication network control element may be configured to control at least one
20 communication cell in which the communication element may be able to communicate with the communication network, wherein the communication element may be one of a communication terminal, a communication device, and a user equipment.

25 According to another example of an embodiment, there is provided, for example, a method including obtaining configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the configuration information indicates at least one association between an
30 instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed; receiving an instruction for a connection state reporting mode; acquiring information related to interference characteristic to be assumed in a current

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communication situation by using the association; and conducting a communication processing by using the acquired information.

Moreover, according to another example of an embodiment, there is provided, for example, an apparatus including at least one processing circuitry, and at least one memory for storing instructions to be executed by the processing circuitry, wherein the at least one memory and the instructions are configured to, with the at least one processing circuitry, cause the apparatus at least: to obtain configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed; to receive an instruction for a connection state reporting mode; to acquire information related to interference characteristic to be assumed in a current communication situation by using the association; and to conduct a communication processing by using the acquired information.

According to further refinements, these examples may include one or more of the following features:

- the communication processing may include at least one of a connection state reporting processing including calculating a connection state feedback wherein the acquired information related to the interference characteristic to be assumed is used as a basis for the connection state feedback calculation, and causing a transmission of the calculated connection state feedback to the communication network; and a demodulation processing in a predetermined number of subframes following after receiving the instruction for a connection state reporting mode, wherein the acquired information related to the interference characteristic to be assumed is used in the demodulation processing in the predetermined number of subframes.

- the configuration information may be obtained from a higher layer signaling between the communication element and the communication network;

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- the instruction for the connection state reporting mode may include one of a periodic channel state information reporting mode and an aperiodic channel state information reporting mode;

- the at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed may be indicated by a mapping of a specific value of a request field used for instructing the connection state reporting mode and a radio resource control signaling indicating a specific characteristic of an interference source or at least one subset of a radio resource control signaling;

- the interference characteristic to be assumed may be indicated by parameters related to at least one of a receiver type of a communication in the communication network, a transmission mode used in a communication in the communication network, a transmission scheme used in a communication in the communication network, a resource allocation in a communication in the communication network, a parameter subset including at least one of a codebook subset based on an antenna type, a subset of virtual cell identifications, a subset of physical cell identifications, a subset of power offset values, a subset of reference signals, a subset of interference measurement resources, a subset of precoding matrix indicators, a subset of modulations orders, a subset of time division duplex downlink/uplink configurations, a target number of interferers to be canceled and a subset of a radio resource control signaling;

- the processing may be implemented in a communication element being one of a communication terminal, a communication device, and a user equipment, wherein the communication element is communicating in a communication cell of the communication network, the communication cell being controlled by a communication network control element of the communication network.

In addition, according to embodiments, there is provided, for example, a computer program product for a computer, including software code portions for performing the steps of the above defined methods, when said product is run on the computer. The computer program product may include a

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computer-readable medium on which said software code portions are stored. Furthermore, the computer program product may be directly loadable into the internal memory of the computer and/or transmittable via a network by means of at least one of upload, download and push procedures.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows a diagram illustrating a general configuration of a communication network where some examples of embodiments are implementable;

Fig. 2 shows a signaling diagram illustrating an example of embodiments;

Fig. 3 shows a time chart illustrating an example of embodiments;

Fig. 4 shows a flow chart of a processing conducted in a communication network control element according to some examples of embodiments;

Fig. 5 shows a flow chart of a processing conducted in a communication element according to some examples of embodiments;

Fig. 6 shows a diagram of a communication network control element according to some examples of embodiments; and

Fig. 7 shows a diagram of a communication element according to some examples of embodiments.

DESCRIPTION OF EMBODIMENTS

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In the last years, an increasing extension of communication networks, e.g. of wire based communication networks, such as the Integrated Services Digital Network (ISDN), DSL, or wireless communication networks, such as the cdma2000 (code division multiple access) system, cellular 3rd generation (3G) like the Universal Mobile Telecommunications System (UMTS), and fourth generation (4G) communication networks or enhanced communication networks based e.g. on LTE or LTE-A, cellular 2nd generation (2G) communication networks like the Global System for Mobile communications (GSM), the General Packet Radio System (GPRS), the Enhanced Data Rates for Global Evolution (EDGE), or other wireless communication system, such as the Wireless Local Area Network (WLAN), Bluetooth or Worldwide Interoperability for Microwave Access (WiMAX), took place all over the world. Various organizations, such as the 3rd Generation Partnership Project (3GPP), Telecoms & Internet converged Services & Protocols for Advanced Networks (TISPAN), the International Telecommunication Union (ITU), 3rd Generation Partnership Project 2 (3GPP2), Internet Engineering Task Force (IETF), the IEEE (Institute of Electrical and Electronics Engineers), the WiMAX Forum and the like are working on standards for telecommunication network and access environments.

Generally, for properly establishing and handling a communication connection between terminal devices such as a user device or user equipment (UE) and another communication network element or user device, a database, a server, host etc., one or more network elements such as communication network control elements, for example access network elements like access points, base stations, eNBs etc. and core network elements or functions, for example control nodes, support nodes, service nodes, gateways etc. are involved, which may belong to different communication network systems.

In the following, some examples of embodiments are described with reference to the drawings, wherein, as an example of a communication network, a cellular wireless communication network, such as an LTE or LTE-

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Advanced based system, is used. However, it is to be noted that the present invention is not limited to an application using such types of communication systems, but is also applicable in other types of communication systems, be it wireless systems, wired systems or systems using a combination thereof.

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The following examples and embodiments are to be understood only as illustrative examples. Although the specification may refer to "an", "one", or "some" example(s) or embodiment(s) in several locations, this does not necessarily mean that each such reference is related to the same example(s) or embodiment(s), or that the feature only applies to a single example or embodiment. Single features of different embodiments may also be combined to provide other embodiments. Furthermore, terms like "comprising" and "including" should be understood as not limiting the described embodiments to consist of only those features that have been mentioned; such examples and embodiments may also contain features, structures, units, modules etc. that have not been specifically mentioned.

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A basic system architecture of a communication system where examples of embodiments are applicable may include an architecture of one or more communication networks including a wired or wireless access network subsystem and a core network. Such an architecture may include one or more communication network control elements, access network elements, radio access network elements, access service network gateways or base transceiver stations, such as a base station (BS), an access point or an eNB, which control a respective coverage area or cell and with which one or more communication elements or terminal devices such as a UE or another device having a similar function, such as a modem chipset, a chip, a module etc., which can also be part of an element, function or application capable of conducting a communication, such as a UE, an element or function usable in a machine to machine communication architecture, or attached as a separate element to such an element, function or application capable of conducting a communication, or the like, are capable to communicate via one or more channels for transmitting several types of data. Furthermore, core network elements such as gateway network elements, policy and

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charging control network elements, mobility management entities, operation and maintenance elements, and the like may be included.

5 The general functions and interconnections of the described elements, which also depend on the actual network type, are known to those skilled in the art and described in corresponding specifications, so that a detailed description thereof is omitted herein. However, it is to be noted that several additional network elements and signaling links may be employed for a communication to or from an element, function or application capable of
10 conducting a communication, like an UE, and a communication network besides those described in detail herein below.

The communication network is also able to communicate with other networks, such as a public switched telephone network or the Internet. The
15 communication network may also be able to support the usage of cloud services. It should be appreciated that network elements of the access system, such as BSs and/or eNBs, of a core network etc., and/or respective functionalities may be implemented by using any node, host, server or access node etc. entity suitable for such a usage.

20 Furthermore, the described network elements, such as terminal devices, communication network control elements of a cell, like a BS or an eNB, access network elements and the like, core network elements etc. as well as corresponding functions as described herein, and other elements, functions
25 or applications capable of conducting a communication may be implemented by software, e.g. by a computer program product for a computer, and/or by hardware. For executing their respective functions, correspondingly used devices, nodes or network elements may include several means, modules, units, components, etc. (not shown) which are required for control,
30 processing and/or communication/signaling functionality. Such means, modules, units and components may include, for example, one or more processors or processor units including one or more processing portions for executing instructions and/or programs and/or for processing data, storage or memory units or means for storing instructions, programs and/or data,

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for serving as a work area of the processor or processing portion and the like (e.g. ROM, RAM, EEPROM, and the like), input or interface means for inputting data and instructions by software (e.g. floppy disc, CD-ROM, EEPROM, and the like), a user interface for providing monitor and manipulation possibilities to a user (e.g. a screen, a keyboard and the like), other interface or means for establishing links and/or connections under the control of the processor unit or portion (e.g. wired and wireless interface means, radio interface means including e.g. an antenna unit or the like, means for forming a radio communication part etc.) and the like, wherein respective means forming an interface, such as a radio communication part, can be also located on a remote site (e.g. a radio head or a radio station etc.). It is to be noted that in the present specification processing portions should not be only considered to represent physical portions of one or more processors, but may also be considered as a logical division of the referred processing tasks performed by one or more processors.

It should be appreciated that according to some examples, a so-called "liquid" or flexible network concept may be employed where the operations and functionalities of a communication network element, network function, or of another entity of the communication network, such as of one or more of radio access network elements like a BS or eNB, may be performed in different entities or functions, such as in a node, host or server, in a flexible manner. In other words, a "division of labour" between involved network elements, functions or entities may vary case by case.

With regard to Fig. 1, a diagram illustrating a general configuration of a communication network is shown where examples of embodiments of the invention are applicable. It is to be noted that the structure indicated in Fig. 1 shows only those devices, network elements and links which are useful for understanding principles underlying the examples of embodiments of the invention. As also known by those skilled in the art there may be several other network elements or devices involved in a connection between a communication element (for example a UE) and the network which are omitted here for the sake of simplicity.

In Fig. 1, reference sign 10 denotes a communication element such as a UE or the like which is capable of communicating with different at least one communication network, for example via one or more carriers and channels.

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Reference sign 20 denotes a communication network control element such as a base station or eNB controlling a communication area or cell (indicated by a dashed line) 200. It is to be noted that there may be several cells in the communication network which are controlled, for example, by the eNB 20 or by another communication network control element. For example, a communication area or cell 250 is shown which is controlled by another communication network control element such as a base station or eNB 25.

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In addition to the UE 10, other communication elements, such as for example UE 15 and UE 16, may be located in a respective communication area or cell and conduct a communication, for example with the corresponding eNB (e.g. eNB 20 or 25).

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As indicated in Fig. 1, control information or data can be exchanged between the communication network control elements and the communication elements (for example indicated by a dashed arrow between eNB 20 and UE 10). Furthermore, data can also be exchanged between the respective communication network control elements, e.g. between eNB 20 and eNB 25 by means of a corresponding interface, such as for example a backhaul connection using a so-called X2 link (indicated in Fig. 1 by a solid line).

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It is to be noted that the communications conducted between a communication element such as UE 10, 15 or 16 and the communication network may be based on similar communication techniques, such as a 3GPP based LTE or LTE-A communication system, or different techniques, which include, for example, a communication system using a WLAN/WiFi system or the like.

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However, when plural communications are conducted at the same time, interferences may be caused between these communications which may deteriorate the communication quality. In general, interference is created by the data traffic of the UEs as well as common signals and channels transmitted in a cell.

A plurality of interference forms can be observed: for example, a so-called inter-stream interference may happen due to e.g. a non-orthogonality of spatial MIMO streams dedicated to the same UE (the so called SU-MIMO interference). Another form is a so-called inter-user interference which can arise between users served in the same cell (e.g. UEs 10 and 15 in cell 200), for example when sharing the same resources (the so called MU-MIMO interference). As a further form, interference may happen among UEs located in different cells (e.g. UE 10 in cell 200 and UE 16 in cell 250 in Fig. 1), which is also called also inter-cell interference. UEs located at the cell edge are suffering in particular by the inter-cell interference.

A plurality of techniques and approaches are proposed and implemented in order to cancel or suppress interferences in communications as far as possible. Cancellation or suppression of, for example, inter-cell interferences may lead to a significant improvement of both cell capacity and coverage. For example, schemes for cancellation and suppression of interferences based on information provided by the communication network are studied, for example in connection with LTE-Advanced communication system, wherein advanced receivers may be operated which implement a NAICS specification.

However, sending assistance information characterizing for example the interference caused by an interference source (also referred to as an aggressor), i.e. an interference structure to a victim of this aggressor may be complicated. For example, a case can be considered where the aggressor is located in a neighboring cell controlled by another eNB (e.g. eNB 25), while the victim is located in a cell potentially controlled by another eNB (e.g. eNB 20), making the delivery of suitable information complex. In this

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context, it is to be noted that this applies to homogeneous and heterogeneous network deployment scenarios.

5 As indicated in Fig. 1, it is possible to convey corresponding information between the respective cell by means of using a backhaul connection, i.e. the eNBs serving the aggressor and victim UEs are connected e.g. through an X2 interface.

10 Basically, interference cancellation/suppression using information provided by the network, such as NAICS, allow to enhance the interference cancellation/interference suppression capability of the UEs by providing more support from the network side. For example, NAICS operation may be based on higher layer signaling network assistance and UE blind detection. The higher layer signaling is applied in particular to interference parameters
15 that are static/semi-static by nature, such as system bandwidth, CP length, number of CRS ports, MBSFN subframe configuration, set of VCIs, etc. On the other hand, a UE in NAICS operation may be configured to blindly detect most, if not all the dynamic parameters, such as PMI, RI, modulation, TM/TS, etc.. As the NAICS operation is based on network
20 assistance, higher layer NAICS signaling enables interference cancellation at the UE side.

In order to perform link adaptation, including for example a correct selection of MCS/TBS, transmission rank and the precoder weights, the
25 communication network (i.e. the communication network control element such as the eNB) requires information about a connection state of the communication conducted with the UE. For example, corresponding information is provided by means of a CSI feedback from the UE. It is to be noted that such a connection state feedback (e.g. a CSI feedback) is also of
30 importance in interference cancellation/suppression, for example based on a NAICS operation, since availability of information on the interference characteristics may directly translate into a higher reported CQI, for example.

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In order to improve the performance of the interference cancellation/suppression, it is conceived that a connection state reporting mechanism, such as a CSI reporting mechanism, takes into account the possible presence of assistance information related to an interference characteristic. That is, since the communication network may have information about a present interference situation at the time a UE calculates connection state information, such as a CSI, this information is made available to the UE. By means of this, it is possible, for example, to avoid a situation where a reported CQI is either pessimistic (calculated assuming no interference cancellation or suppression is made), or overly optimistic (assuming interference can be cancelled when that is not the case). Hence, according to examples of embodiments, measures are provided which ensure that the connection state (e.g. the CSI) reported in an interference cancellation/suppression operation (e.g. based on NAICS specification) reflects correctly the interference situation, taking into account the receiver's (i.e. UE's) capabilities of handling interference.

In the following, examples of embodiments are described where, as a mechanism for reporting a connection state, a so-called CSI reporting mechanism is used, which is employed, for example, in LTE or LTE-A based systems. However, the principles defined in connection with the examples of embodiments described below are also applicable to other mechanisms where a connection or channel state is reported from a communication element, such as a UE or the like, to a communication network control element, such as a BS, an eNB or the like.

In wireless communications, CSI refers to channel properties of a connection or communication link. It describes how a signal propagates from a transmitter to a receiver, wherein effects of, for example, scattering, fading, and power decay with distance are reflected. The CSI makes it possible to adapt transmissions to current channel conditions and hence to achieve a reliable communication with high data rates e.g. in multi-antenna systems. CSI is computed at the receiver and usually quantized and fed back to the transmitter.

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CSI includes, for example, information related to a channel quality indicator (CQI), which indicates e.g. a suitable downlink transmission data rate, a precoding matrix indicator (PMI), a precoding type indicator, and/or rank indication (RI), which is used e.g. to indicate the number of different data streams to be transmitted simultaneously on the same time and frequency resources. It is to be noted that the time and frequency resources that can be used by the UE to report the CSI are controlled by the eNB.

It is possible to configure different forms or types for reporting a connection state. In case of CSI reporting, for example, periodic and/or aperiodic feedback mode can be implemented.

In periodic CSI reporting mode, the CSI feedback is transmitted from the UE to the eNB with a certain interval which is specified, for example, by a higher layer message (e.g. RRC connection reconfiguration message, RRC connection setup message). Usually, a connection state reporting mode including e.g. periodic CSI reporting is limited by an available UL payload of a transport channel to be used. For example, in case of using PUCCH format 2, the maximum is just 11 bits / report. Therefore, periodic CSI reports typically carry only coarse wideband information.

In aperiodic CSI reporting mode, a CSI feedback is triggered by sending a corresponding instruction, for example, from the eNB to the UE. The format of such a CSI feedback trigger or instruction may comprise one bit, two bits or even more bits. As a transport medium, for example, an UL grant message transmitted over PDCCH can be implemented.

On the other hand, the payload of aperiodic reports transmitted over PUSCH may be greater than that of a periodic report. For example, up to 100 bits or more can be used as payload, wherein the respective aperiodic reports or feedbacks may contain detailed information about CQI/PMI also in frequency domain.

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In order to improve an interference cancellation and suppression technique using network assistance, such as NAICS, according to examples of embodiments, a configuration for a connection state reporting, such as a CSI reporting configuration, is utilized to convey information on an assumed or measured interference structure or interference characteristic.

Specifically, according to examples of embodiments, when, for example, an aperiodic CSI reporting mode is used, each aperiodic triggering state for a CSI feedback (signaled with two or more bits, for example, in a predetermined field in a PDCCH UL grant) is associated with an assumption of a certain interference characteristic or structure related to an interference source (the aggressor). In other words, certain information related to an interference characteristic or structure are associated with (or mapped on) a certain instruction parameter or format for the CSI reporting. In this case, the UE computes a CSI feedback on the assumption that this assumed interference characteristic or structure is valid. In this context, it is assumed to be evident for a person skilled in the art how information indicated in the interference characteristic or structure are implemented in a calculation of the CSI feedback or of corresponding parameters. For example, any availability of interferer parametrization like PA, PMI subset, TM, etc, is reducing the blind detection error probability at the UE and improves the identification of the dominant interferer effective wireless channel and modulation information.

Alternatively or additionally, according to examples of embodiments, when, for example, a connection state reporting mode like a periodic CSI reporting mode is used, different reporting processes are configured to assume a specific interference characteristic or structure. For example, a value of an interval/a periodicity, PUCCH resource, and/or subframe offset set by the higher layer signaling is used for associating a specific interference characteristic or structure with the current CSI reporting mode. Thus, for example, CSI feedback reports corresponding to different interference characteristics or structure may alternate in time. In other words, there may be configured multiple periodic processes, each with a different

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assumption on the interference characteristics. Each CSI process may be configured separately, i.e. having a distinct reporting periodicity, a subframe offset, PUCCH resource configuration, etc. When the UE provides a connection state report, such as a CSI feedback, for a given process as configured, it also assumes the configured interference characteristics. That is, it is possible to configure the CSI reporting for different processes having different interference characteristics so that the periodic reports alternate, i.e. each report corresponds to a different interference hypothesis.

According to further examples of embodiments, the UE is configured to use the association between the received instruction (e.g. the CSI feedback trigger having a certain value) and an interference characteristic to be assumed in a communication processing. The communication processing is, for example, the calculation and transmission of the requested connection state feedback, wherein the interference structure indicated in association with the instruction for the periodic/aperiodic CSI reporting is used for the calculation. Alternatively or additionally, the UE is configured to utilize the interference structure indicated by the periodic/aperiodic CSI reporting instruction also as an assumption for the interference structure for a demodulation processing or stage.

Fig. 2 shows a signaling diagram illustrating a procedure used for improving the interference cancellation and suppression according to some examples of embodiments. Specifically, Fig. 2 is related to a signaling and processing conducted between a communication network control element, such as, for example, the eNB 20 shown in Fig. 1, and a communication element, such as, for example, the UE 10 shown in Fig. 1, which is communicating with the communication network. In the example shown in Fig. 2, it is assumed that both the eNB 20 and the UE 10 are capable of performing a processing related to a network assisted interference cancellation and suppression operation, such as NAICS.

In S10, the UE 10 obtains, for example from the eNB 20, configuration information related to the connection state reporting, such as CSI reporting

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configuration information. The CSI reporting configuration information includes RRC signaling information indicating the association between the instruction for the connection state reporting (e.g. the value of a CSI request field) and the interference structure through the serving cell (e.g. cell 200).

According to some examples of embodiments, in S10, the UE 10 receives also an additional indication related to an interference hypothesis consisting of one or more interference parameters. These interference parameters may be a subset of the NAICS RRC signaling. In other words, according to some examples of embodiments, the serving cell/eNB 20 sends to the UE 10 the NAICS RRC signaling indicating interferer characteristics and how they are associated with an instruction for a connection state reporting mode, such as aperiodic CSI triggering states. As indicated above, the RRC signaling may consist of predefined hypothesis/subsets consisting of interference parameters (subsets of parameters).

In S20, the serving cell/eNB 20 sends to the UE 10 an instruction for connection state reporting, such as a CSI reporting (feedback) trigger. For example, an aperiodic CSI feedback trigger is sent to the UE 10 in connection with a PDCCH UL Grant message. The instruction is sent to the UE 10 considering an interference characteristic for a current communication between the UE 10 and the eNB 20, that is, the connection state reporting instruction, e.g. the CSI feedback trigger sent to the UE 10 is selected or generated under consideration of the association between the instructions and the interference characteristics to be assumed as indicated in the configuration information provided in S10. For example, an aperiodic CSI feedback trigger is sent to the UE 10 having a predetermined value, e.g. of 1 bit, or two or more bits which is/are associated to a (defined) interference characteristic which coincides (at least in part) with a current interference characteristic or structure. It is to be noted that information or parameters related to the current interference characteristic or structure can be determined in the requesting eNB 20 e.g. by means of own measurements or calculations, on the basis of information provided for

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example from another source (e.g. the eNB 25), or the like. The instruction to be sent to the UE 10 is then selected, for example, on the basis of a comparison between the determined interference structure and the respective interference structures associated with instruction values (which are provided to the UE 10 by means of the configuration information in S10, for example). In other words, according to one possible example, the determined interference structure is compared with interference structures corresponding to those indicated in connection with the configuration information, wherein the instruction to be used is selected which is associated with the interference characteristic whose parameters are decided to be the best match for the presently determined interference characteristic. In this context, also weighting factors can be considered, i.e. certain parameters may be assumed to be more important than others.

When the UE 10 receives the instruction in S20, e.g. the aperiodic CSI feedback trigger on PDCCH UL Grant message, in S30, a communication processing is conducted by the UE 10, wherein an interference characteristic or structure to be assumed is derived from the configuration information on the basis of an evaluation of the received instruction form. For example, in S30, the UE 10 computes the CSI feedback according to the indicated assumption on the interference structure.

Additionally or alternatively, in case of e.g. a connection state reporting mode including e.g. an aperiodic reporting, the UE 10 may be configured to assume in a demodulation stage that the same interference characteristic or structure is valid not only for a CSI calculation, but can also be utilized for demodulation. Consequently, a demodulation based on the interference characteristic to be assumed can also be performed. According to examples of embodiments, this assumption is assumed to be valid only for a predetermined time, e.g. a predetermined number N of following subframes after the receipt of the instruction such as aperiodic feedback CSI trigger in the PDCCH UL grant. The number N may be set, for example, by means of higher signaling, or may be a fixed value stored in the UE and set in the specification, or the like.

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In S40, the UE 10 reports the CSI feedback to the eNB 20. The serving cell/eNB 20 receives the requested CSI feedback according to the indicated assumptions.

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Then, in S50, a link adaptation is conducted on the basis of the received CSI report. For example, the serving cell/eNB 20 schedules resources, such as a PDSCH to the UE 10.

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According to examples of embodiments, information or parameters related to the interference structure / characteristics may include data being related to one or more of the following: a receiver type involved in the communication being interfered, a transmission mode of the communication, a transmission scheme of the communication, a resource allocation for the communication, various types of parameter subsets, for example codebook subsets based on an antenna type (cross polarized or ULA), subsets of VICs/PICs, subsets of power offset values PA, specific values for PMI, RI, modulation order, number of interferers to be canceled, etc.. It is to be noted that this list is not limiting the possible information or parameters being usable in examples of embodiments, wherein, one, two, more than two of these data can be considered.

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With regard to the association of an instruction value for a specific connection state reporting mode and one or more of these interference characteristics, in the following, specific examples will be described. It is to be noted that the following examples are only for illustrative purpose. There is a plurality of other association forms or options which are applicable correspondingly. Furthermore, an example is described where the instruction regarding the connection state reporting mode is provided by two bits, wherein, as indicated above, also one bit or more bits can be used.

Assuming that the association is provided by different CSI reporting options and RRC signaling. When an example is related to an aperiodic CSI reporting mode and the interference characteristic is related to a

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transmission mode of the interferer, the association between a corresponding value of a CSI request field and an interference characteristic to be assumed can be as follows.

5 For a CSI request field value of "00", it is defined that no (aperiodic) CSI reporting is triggered.

For a CSI request field value of "01", it is defined that an (aperiodic) CSI reporting is triggered for a serving cell wherein it is assumed that no
10 information about the interference characteristic or structure is available.

For a CSI request field value of "10", it is defined that an (aperiodic) CSI reporting is triggered for a serving cell wherein it is assumed that an interference source uses a first transmission mode (e.g. a transmission
15 mode 3).

For a CSI request field value of "11", it is defined that an (aperiodic) CSI reporting is triggered for a serving cell wherein it is assumed that an interference source uses a second transmission mode (e.g. a transmission
20 mode 9).

Furthermore, even though in the above described example a transmission mode is used for the indication of an interference characteristic, it is of course possible to consider other parameters or additional parameters as
25 listed above, according to the RRC configured message.

Next, a further example is described where again it is assumed that the association is provided by different CSI reporting options and RRC signaling. In the present example, a more generic operation is considered where
30 states of the CSI request field (i.e. instructions for a connection state reporting mode) are associated with RRC signaling or with subset configurations of the RRC signaling. According to examples of embodiments, such RRC subsets include different interference hypothesis. For example, an RRC subset1 including parameters according to: {PCI1, VCI1, CSI-RS1,

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IMR1, PA1, TMx, PMI subset1} and an RRC subset2 including parameters according to: {PCI2, VCI2, CSI-RS2, IMR2, PA2, TMx, PMI subset2} are defined. Correspondingly, an example is related to an aperiodic CSI reporting mode and the interference characteristic is related to a RRC signaling or subset of RRC signaling, the association between a corresponding value of a CSI request field and an interference characteristic to be assumed can be as follows.

For a CSI request field value of "00", it is defined that no (aperiodic) CSI reporting is triggered.

For a CSI request field value of "01", it is defined that an (aperiodic) CSI reporting is triggered for a serving cell wherein it is assumed that no information about the interference characteristic or structure is available.

For a CSI request field value of "10", it is defined that an (aperiodic) CSI reporting is triggered for a serving cell wherein it is assumed that an interference source uses RRC subset1.

For a CSI request field value of "11", it is defined that an (aperiodic) CSI reporting is triggered for a serving cell wherein it is assumed that an interference source uses RRC subset2.

It is to be noted that the RRC subsets may also include parameters or parameter subsets as an RRC subset3: {PCI subset1, VCI subset1, ZP and/or NZP CSI-RS subset 1, IMR subset 1, PA subset 1, TM subset, PMI subset1, modulation order subset 1, numbers_of_interferers to be canceled, resource allocation type, TDD UL/DL configuration}

According to further examples of embodiments, the CSI request field may be also associated with a receiver type assumption like receivers performing interference suppressions, like enhanced IRC, or receivers performing interference cancellation, like SLIC/R-ML. The CSI request field may be

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further associated with different types of interference cancelation, for example PDSCH IC, CRS IC, PDCCH IC, ePDCCH IC, etc.

5 In case an instruction represent by a data set like the above described CSI request field allows more than two bits, for example, it is possible that further associations can be defined.

10 Next, with reference to Fig. 3, a time flow of the interference procedure according to examples of embodiments for improving the interference cancellation and suppression is illustrated by means of a sequence of subframes of a communication.

15 As shown in Fig. 3, a time frame of 16 subframes 0 to 15 is considered. At a time point corresponding to subframe #2, the UL grant message including the instruction for the connection state reporting mode, such as an aperiodic CSI feedback trigger, (see S10 in Fig. 2) is assumed to be received by the UE 10. As described above, the instruction provides also an indication of an interference structure/characteristic to be assumed to be present (by means of the association described above, for example). This
20 assumed interference structure/characteristic is used in connection with the communication processing of the UE 10.

Namely, at a time point corresponding to subframe #6, it is assumed that the calculation of the CSI feedback is completed, so that the UE 10
25 transmits the CSI feedback to the (requesting) eNB 20 (see S40 in Fig. 2).

However, as also indicated above, as another communication processing which is conducted additionally or alternatively, the UE 10 utilizes the interference assumption provided by the association of the instruction also
30 in the data demodulation processing for a predetermined number N of subframes following to the reception of the PDCCH UL grant carrying the CSI feedback trigger (subframe #2). This is indicated in Fig. 3 by means of the arrow labeled by N.

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The value of N can be e.g. a fixed value or a configurable value being set via a higher layer signaling or the like, such as RRC signaling.

5 It is to be noted that according to further examples, the predetermined number N of subframes can also be started to be counted after a transmission of the corresponding CSI feedback, i.e. after subframe #6, for example (see dashed arrow in Fig. 3).

10 Thus, according to examples of embodiments, it is possible, for example, to provide a mechanism for e.g. LTE-A communication networks to improve interference suppression/cancellation by means of CSI reporting procedure. For example, it is possible to overcome a situation where a CSI feedback determined by a UE does not reflect the current interference situation at the time of determination, since the UE can now be provided with specific
15 knowledge about the interference situation. Specifically, each CSI triggering state is associated with predefined information about an interference characteristic, wherein this is provided to the UEs of a cell. The UE is then able to use this association so as to determine the CSI and to transmit it back to the network. In this manner, the UE is able to provide a more
20 accurate CSI feedback.

That is, according to examples of embodiments, the CSI triggering signaling in NAICS is resolved by associating the CSI request field with RRC configuration parameters and receiver types.

25 By means of the above described interference cancellation and suppression procedure, it is possible that the communication network control element, such as the eNB 20, is provided with flexibility regarding to dynamically switch ON/OFF NAICS feature by means of selecting a corresponding
30 instruction for a connection state reporting mode, such as a aperiodic CSI feedback trigger, while in addition it is possible to indicate the current interference structure.

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Furthermore, it is possible to provide two main issues related to, for example, NAICS since CSI feedback and dynamic assistance signaling for data demodulation can be provided by one measure.

5 Moreover, examples of embodiments are efficient with regard to signaling load, since, for example, RRC signaling is needed only upon configuring the CSI reporting. Furthermore, when utilizing the interference structure indicated by the periodic/aperiodic CSI reporting instruction also as an assumption for the interference structure for a demodulation processing or
10 stage, extra signaling for this purpose can be avoided.

In addition, it is possible to minimize specification changes needed, while providing the full benefits of e.g. NAICS.

15 Fig. 4 shows a flow chart of a processing conducted in a communication network control element according to some examples of embodiments. For example, the processing is executed by a communication network control element of communication network controlling at least one communication cell in which a communication element is able to communicate with the
20 communication network, wherein the communication element is one of a communication terminal, a communication device, and a user equipment.

In S100, configuration information related to a reporting procedure of a connection state of a communication (e.g. CSI reporting) between a
25 communication element (e.g. UE 10) and a communication network (e.g. represented by eNB 20) is provided. The configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by the communication element and an interference characteristic to be assumed.

30 In S110, a transmission of an instruction for a connection state reporting mode (e.g. a CSI feedback trigger) is caused. The instruction to be transmitted is selected in accordance with an interference characteristic in a current communication situation.

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According to some examples of embodiments, the interference characteristic in the current communication situation is determined. The determination is based, for example, on an own measurement of parameters related to the interference characteristic (i.e. done e.g. by the eNB 20) and/or an external signaling conveying parameters related to the interference characteristic (e.g. transmitted from the eNB 25). Then, an instruction for a connection state reporting mode is selected on the basis of the determined interference characteristic as the instruction for a connection state reporting mode which is caused to be transmitted. For example, the selecting is based on a comparison of the determined interference characteristic and the interference characteristic to be assumed (i.e. the respective interference characteristics included in the configuration information and associated to the instruction for the connection state reporting mode).

Furthermore, according to some examples of embodiments, a connection state feedback is received in response to the instruction caused to be transmitted. The connection state feedback is processed accordingly, wherein a result thereof is used for performing a link adaptation of the communication between the communication element (UE 10) and the network.

According to some examples of embodiments, the configuration information is provided by using a higher layer signaling (e.g. RRC signaling) between the communication element and the communication network.

Furthermore, according to some examples of embodiments, the instruction for the connection state reporting mode (e.g. the CSI feedback trigger) is related to one of a periodic channel state information reporting mode (e.g. periodic CSI reporting) and an aperiodic channel state information reporting mode (e.g. aperiodic CSI reporting).

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Moreover, according to some examples of embodiments, the association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed is indicated by a mapping of a specific value of a request field used for instructing the connection state reporting mode and a radio resource control signaling indicating a specific characteristic of an interference source or at least one subset of a radio resource control signaling.

In addition, according to some examples of embodiments, the interference characteristic to be assumed is indicated by parameters related to at least one of a receiver type of a communication in the communication network, a transmission mode TM used in a communication in the communication network, a transmission scheme used in a communication in the communication network, a resource allocation in a communication in the communication network, a parameter subset including at least one of a codebook subset based on an antenna type, a subset of VCIs, a subset of PCIs, a subset of power offset values (PA), a subset of reference signals, a subset of IMRs, a subset of PMIs, a subset of modulations, a subset of TDD DL/UL configuration, a target number of interferers to be canceled, and a subset of an RRC signaling.

Fig. 5 shows a flow chart of a processing conducted in a communication element according to some examples of embodiments. For example, the processing is executed by a communication element being one of a communication terminal, a communication device, and a user equipment, wherein the communication element is communicating in a communication cell of the communication network, the communication cell being controlled by a communication network control element of the communication network.

In S200, configuration information related to a reporting procedure of a connection state of a communication (e.g. a CSI reporting) between a communication element (e.g. UE 10) and a communication network (represented e.g. by the eNB 20) is obtained. The configuration information

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indicates at least one association between an instruction for a connection state reporting mode (e.g. CSI feedback trigger) to be used by a communication element and an interference characteristic to be assumed.

5 In S210, an instruction for a connection state reporting mode (e.g. a CSI feedback trigger) is received and processed.

In S220, information related to interference characteristic to be assumed in a current communication situation is acquired by using the association.

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In S230, a communication processing is conducted by using the acquired information.

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According to some examples of embodiments, the communication processing in S230 comprises at least one of a connection state reporting processing and a demodulation processing.

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In the connection state reporting processing (e.g. CSI reporting processing), a connection state feedback (e.g. CSI feedback) is calculated wherein the acquired information related to the interference characteristic to be assumed is used as a basis for the connection state feedback calculation, wherein the calculated connection state feedback is transmitted to the communication network (e.g. to the eNB 20).

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In the demodulation processing, a demodulation is executed in a predetermined number (N) of subframes following after receiving the instruction for a connection state reporting mode (e.g. the CSI feedback trigger). In the demodulation conducted in these subframes, the acquired information related to the interference characteristic to be assumed is used.

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According to some examples of embodiments, the configuration information is provided by using a higher layer signaling (e.g. RRC signaling) between the communication element and the communication network.

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Furthermore, according to some examples of embodiments, the instruction for the connection state reporting mode (e.g. the CSI feedback trigger) is related to one of a periodic channel state information reporting mode (e.g. periodic CSI reporting) and an aperiodic channel state information reporting mode (e.g. aperiodic CSI reporting).

Moreover, according to some examples of embodiments, the association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed is indicated by a mapping of a specific value of a request field used for instructing the connection state reporting mode and a radio resource control signaling indicating a specific characteristic of an interference source or at least one subset of a radio resource control signaling.

In addition, according to some examples of embodiments, the interference characteristic to be assumed is indicated by parameters related to at least one of a receiver type of a communication in the communication network, a transmission mode TM used in a communication in the communication network, a transmission scheme used in a communication in the communication network, a resource allocation in a communication in the communication network, a parameter subset including at least one of a codebook subset based on an antenna type, a subset of VCIs, a subset of PCIs, a subset of power offset values (PA), a subset of reference signals, a subset of IMRs, a subset of PMIs, a subset of modulations, a subset of TDD DL/UL configuration, a target number of interferers to be canceled and a subset of an RRC signaling.

Fig. 6 shows a diagram of a communication network control element according to some examples of embodiments, which is configured to implement the interference cancellation and suppression procedure as described in connection with some of the examples of embodiments. It is to be noted that the communication network control element, like eNB 20, which is shown in Fig. 6, may include further elements or functions besides those described herein below. Furthermore, even though reference is made

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to a communication network control element, the element may be also another device or function having a similar task, such as a chipset, a chip, a module, an application etc., which can also be part of a communication network control element or attached as a separate element to a communication network control element, or the like. It should be understood that each block and any combination thereof may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry.

The communication network control element shown in Fig. 6 may include a processing circuitry, a processing function, a control unit or a processor 21, such as a CPU or the like, which is suitable for executing instructions given by programs or the like related to the interference cancellation and suppression procedure. The processor 21 may include one or more processing portions or functions dedicated to specific processing as described below, or the processing may be run in a single processor or processing function. Portions for executing such specific processing may be also provided as discrete elements or within one or more further processors, processing functions or processing portions, such as in one physical processor like a CPU or in one or more physical or virtual entities, for example. Reference signs 22 and 23 denote transceiver or input/output (I/O) units or functions (interfaces) connected to the processor or processing function 21. The I/O units 22 may be used for communicating with one or more communication elements, such as UE 10, and the like. The I/O units 23 may be used for communicating with one or more network elements, such as other communication network control elements (such as eNB 25 via X2 link), but also with core network elements, and the like. The I/O units 22 and 23 may be a combined unit including communication equipment towards several network elements, or may include a distributed structure with a plurality of different interfaces for different network elements. Reference sign 24 denotes a memory usable, for example, for storing data and programs to be executed by the processor or processing function 21 and/or as a working storage of the processor or processing function 21.

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The processor or processing function 21 is configured to execute processing related to the above described interference cancellation and suppression procedure. In particular, the processor or processing circuitry or function 21 includes a sub-portion 211 as a processing portion which is usable for providing configuration information. The portion 211 may be configured to perform processing according to S100 of Fig. 4. Furthermore, the processor or processing circuitry or function 21 includes a sub-portion 212 usable as a portion for determining an interference characteristic. Furthermore, the processor or processing circuitry or function 21 includes a sub-portion 213 usable as a portion for generating and transmitting an instruction related to a connection state reporting mode (e.g. a CSI feedback trigger). The portion 213 may be configured to perform a processing according to S110 of Fig. 4.

Fig. 7 shows a diagram of a communication element according to some examples of embodiments, which is configured to implement the interference cancellation and suppression procedure as described in connection with some of the examples of embodiments. It is to be noted that the communication element, like UE 10, which is shown in Fig. 7, may include further elements or functions besides those described herein below. Furthermore, even though reference is made to a communication element, the element may be also another device or function having a similar task, such as a chipset, a chip, a module, an application etc., which can also be part of a communication element or attached as a separate element to a communication element, or the like. It should be understood that each block and any combination thereof may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry.

The communication element shown in Fig. 7 may include a processing circuitry, a processing function, a control unit or a processor 11, such as a CPU or the like, which is suitable for executing instructions given by programs or the like related to the interference cancellation and suppression

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procedure. The processor 11 may include one or more processing portions or functions dedicated to specific processing as described below, or the processing may be run in a single processor or processing function. Portions for executing such specific processing may be also provided as discrete elements or within one or more further processors, processing functions or processing portions, such as in one physical processor like a CPU or in one or more physical or virtual entities, for example. Reference sign 12 denotes transceiver or input/output (I/O) units or functions (interfaces) connected to the processor or processing function 11. The I/O units 12 may be used for communicating with one or more communication networks, i.e. communication network control elements, such as eNB 20, and the like. The I/O units 12 may be a combined unit including communication equipment towards several network elements, or may include a distributed structure with a plurality of different interfaces for different network elements. Reference sign 14 denotes a memory usable, for example, for storing data and programs to be executed by the processor or processing function 11 and/or as a working storage of the processor or processing function 11.

The processor or processing function 11 is configured to execute processing related to the above described interference cancellation and suppression procedure. In particular, the processor or processing circuitry or function 11 includes a sub-portion 110 as a processing portion which is usable for obtaining configuration information. The portion 110 may be configured to perform processing according to S200 of Fig. 5. Furthermore, the processor or processing circuitry or function 11 includes a sub-portion 111 usable as a portion for receiving and processing an instruction related to a connection state reporting mode (e.g. a CSI feedback trigger). The portion 111 may be configured to perform processing according to S210 of Fig. 5. Furthermore, the processor or processing circuitry or function 11 includes a sub-portion 113 usable as a portion for acquiring an interference characteristic. The portion 113 may be configured to perform a processing according to S220 of Fig. 5. Moreover, the processor or processing circuitry or function 11 includes a sub-portion 114 usable as a portion for conducting a

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communication processing. The portion 114 may be configured to perform a processing according to S230 of Fig. 5.

5 According to another example of embodiments, there is provided an apparatus including means for providing configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed;
10 and means for causing transmission of an instruction for a connection state reporting mode according to an interference characteristic in a current communication situation.

15 In addition, according to another example of embodiments, there is provided an apparatus including means for obtaining configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the configuration information indicates at least one
20 association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed; means for receiving an instruction for a connection state reporting mode; means for acquiring information related to interference characteristic to be assumed in a current communication situation by using
25 the association; and means for conducting a communication processing by using the acquired information.

It should be appreciated that

- an access technology via which signaling is transferred to and from a
30 network element may be any suitable 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; Additionally, embodiments may also apply wired technologies, e.g. IP based access technologies like cable networks or fixed lines.

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- a user device (also called UE, user equipment, user terminal, terminal device, etc.) illustrates one type of an apparatus to which resources on the air interface may be allocated and assigned, and thus any feature described herein with a user device may be implemented with a corresponding apparatus, such as a relay node. An example of such a relay node is a layer 3 relay (self-backhauling relay) towards a base station or eNB. The user device typically refers to a portable computing device that includes wireless mobile communication devices operating with or without a subscriber identification module (SIM), including, but not limited to, the following types of devices: a mobile station (mobile phone), smartphone, personal digital assistant (PDA), handset, device using a wireless modem (alarm or measurement device, etc.), laptop and/or touch screen computer, tablet, game console, notebook, and multimedia device. It should be appreciated that a user device may also be a nearly exclusive uplink only device, of which an example is a camera or video camera loading images or video clips to a network, or a nearly exclusive downlink only device, such as a portable video player. Also equipment used for measuring certain values, such as sensors which can measure a temperature, a pressure etc., can be used as a corresponding user device. It should be appreciated that a device may be regarded as an apparatus or as an assembly of more than one apparatus, whether functionally in cooperation with each other or functionally independently of each other but in a same device housing.

- embodiments suitable to be implemented as software code or portions of it and being run using a processor or processing function are software code independent and can be specified using any known or future developed programming language, such as a high-level programming language, such as objective-C, C, C++, C#, Java, etc., or a low-level programming language, such as a machine language, or an assembler.

- implementation of embodiments is hardware independent and may be implemented using any known or future developed hardware technology or any hybrids of these, such as a microprocessor or CPU (Central Processing Unit), MOS (Metal Oxide Semiconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL (Emitter Coupled Logic), and/or TTL (Transistor-Transistor Logic).

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- embodiments may be implemented as individual devices, apparatuses, units, means or functions, or in a distributed fashion, for example, one or more processors or processing functions may be used or shared in the processing, or one or more processing sections or processing portions may

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be used and shared in the processing, wherein one physical processor or more than one physical processor may be used for implementing one or more processing portions dedicated to specific processing as described,

- an apparatus may be implemented by a semiconductor chip, a chipset, or a (hardware) module including such chip or chipset;

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- embodiments may also be implemented as any combination of hardware and software, such as ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) or CPLD (Complex Programmable Logic Device) components or DSP (Digital Signal Processor) components.

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- embodiments may also be implemented as computer program products, including a computer usable medium having a computer readable program code embodied therein, the computer readable program code adapted to execute a process as described in embodiments, wherein the computer usable medium may be a non-transitory medium.

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Although the present invention has been described herein before with reference to particular embodiments thereof, the present invention is not limited thereto and various modifications can be made thereto.

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CLAIMS

1. A method including

5 providing configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed; and

10 causing transmission of an instruction for a connection state reporting mode according to an interference characteristic in a current communication situation.

15 2. The method according to claim 1, further including

 determining the interference characteristic in the current communication situation from at least one of an own measurement of parameters related to the interference characteristic and an external signaling conveying parameters related to the interference characteristic; and

20 selecting, as the instruction for a connection state reporting mode which is caused to be transmitted, an instruction for a connection state reporting mode on the basis of the determined interference characteristic.

25 3. The method according to claim 2, wherein the selecting further includes

 comparing the determined interference characteristic and the interference characteristic to be assumed, which is included in the configuration information associated to the instruction for the connection state reporting mode.

30 4. The method according to any of claims 1 to 3, further including

 receiving a connection state feedback in response to the instruction caused to be transmitted;

 processing the connection state feedback; and

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performing a link adaptation on the basis of a result of the processing of the connection state feedback.

5. The method according to any of claims 1 to 4, wherein

5 the configuration information is provided by using a higher layer signaling between the communication element and the communication network.

10 6. The method according to any of claims 1 to 5, wherein the instruction for the connection state reporting mode includes one of a periodic channel state information reporting mode and an aperiodic channel state information reporting mode.

15 7. The method according to any of claims 1 to 6, wherein the at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed is indicated by a mapping of a specific value of a request field used for instructing the connection state reporting mode and a radio resource control signaling indicating a specific characteristic of an
20 interference source or at least one subset of a radio resource control signaling.

25 8. The method according to any of claims 1 to 7, wherein the interference characteristic to be assumed is indicated by parameters related to at least one of

 a receiver type of a communication in the communication network,
 a transmission mode used in a communication in the communication network,

30 a transmission scheme used in a communication in the communication network,

 a resource allocation in a communication in the communication network,

 a parameter subset including at least one of a codebook subset based on an antenna type, a subset of virtual cell identifications, a subset of

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physical cell identifications, a subset of power offset values, a subset of reference signals, a subset of interference measurement resources, a subset of precoding matrix indicators, a subset of modulation orders, a subset of time division duplex downlink/uplink configurations, a target number of interferers to be canceled and a subset of a radio resource control signaling.

9. The method according to any of claims 1 to 8, wherein the method is implemented in a communication network control element of the communication network, wherein the communication network control element is configured to control at least one communication cell in which the communication element is able to communicate with the communication network, wherein the communication element is one of a communication terminal, a communication device, and a user equipment.

10. An apparatus including
at least one processing circuitry,
and
at least one memory for storing instructions to be executed by the processing circuitry, wherein
the at least one memory and the instructions are configured to, with the at least one processing circuitry, cause the apparatus at least:
to provide configuration information related to a reporting procedure of a connection state of a communication between a communication element and a communication network, wherein the configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed; and
to cause transmission of an instruction for a connection state reporting mode according to an interference characteristic in a current communication situation.

11. A method including
obtaining configuration information related to a reporting procedure of a connection state of a communication between a communication

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element and a communication network, wherein the configuration information indicates at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed;

5 receiving an instruction for a connection state reporting mode;
 acquiring information related to interference characteristic to be assumed in a current communication situation by using the association; and
 conducting a communication processing by using the acquired information.

10

12. The method according to claim 11, wherein the communication processing includes at least one of

 a connection state reporting processing including

 calculating a connection state feedback wherein the acquired
15 information related to the interference characteristic to be assumed is used as a basis for the connection state feedback calculation, and
 causing a transmission of the calculated connection state feedback to the communication network; and

 a demodulation processing in a predetermined number of subframes
20 following after receiving the instruction for a connection state reporting mode, wherein the acquired information related to the interference characteristic to be assumed is used in the demodulation processing in the predetermined number of subframes.

25 13. The method according to any of claims 11 and 12, wherein
 the configuration information is obtained from a higher layer signaling between the communication element and the communication network.

 14. The method according to any of claims 11 to 13, wherein the instruction
30 for the connection state reporting mode includes one of a periodic channel state information reporting mode and an aperiodic channel state information reporting mode.

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15. The method according to any of claims 11 to 14, wherein the at least one association between an instruction for a connection state reporting mode to be used by a communication element and an interference characteristic to be assumed is indicated by a mapping of a specific value of a request field used for instructing the connection state reporting mode and a radio resource control signaling indicating a specific characteristic of an interference source or at least one subset of a radio resource control signaling.

16. The method according to any of claims 11 to 15, wherein the interference characteristic to be assumed is indicated by parameters related to at least one of

a receiver type of a communication in the communication network,
a transmission mode used in a communication in the communication network,

a transmission scheme used in a communication in the communication network,

a resource allocation in a communication in the communication network,

a parameter subset including at least one of a codebook subset based on an antenna type, a subset of virtual cell identifications, a subset of physical cell identifications, a subset of power offset values, a subset of reference signals, a subset of interference measurement resources, a subset of precoding matrix indicators, a subset of modulations orders, a subset of time division duplex downlink/uplink configurations, a target number of interferers to be canceled and a subset of a radio resource control signaling.

17. The method according to any of claims 11 to 16, wherein the method is implemented in a communication element being one of a communication terminal, a communication device, and a user equipment, wherein the communication element is communicating in a communication cell of the communication network, the communication cell being controlled by a communication network control element of the communication network.

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18. An apparatus including

at least one processing circuitry,

and

at least one memory for storing instructions to be executed by the
5 processing circuitry, wherein

the at least one memory and the instructions are configured to, with
the at least one processing circuitry, cause the apparatus at least:

to obtain configuration information related to a reporting procedure of
a connection state of a communication between a communication element
10 and a communication network, wherein the configuration information
indicates at least one association between an instruction for a connection
state reporting mode to be used by a communication element and an
interference characteristic to be assumed;

to receive an instruction for a connection state reporting mode;

15 to acquire information related to interference characteristic to be
assumed in a current communication situation by using the association; and

to conduct a communication processing by using the acquired
information.

20 19. A computer program product for a computer, including software code
portions for performing the steps of any of claims 1 to 9 or any of claims 11
to 17 when said product is run on the computer.

20. The computer program product according to claim 19, wherein

25 the computer program product includes a computer-readable medium
on which said software code portions are stored, and/or

the computer program product is directly loadable into the internal
memory of the computer and/or transmittable via a network by means of at
least one of upload, download and push procedures.

30

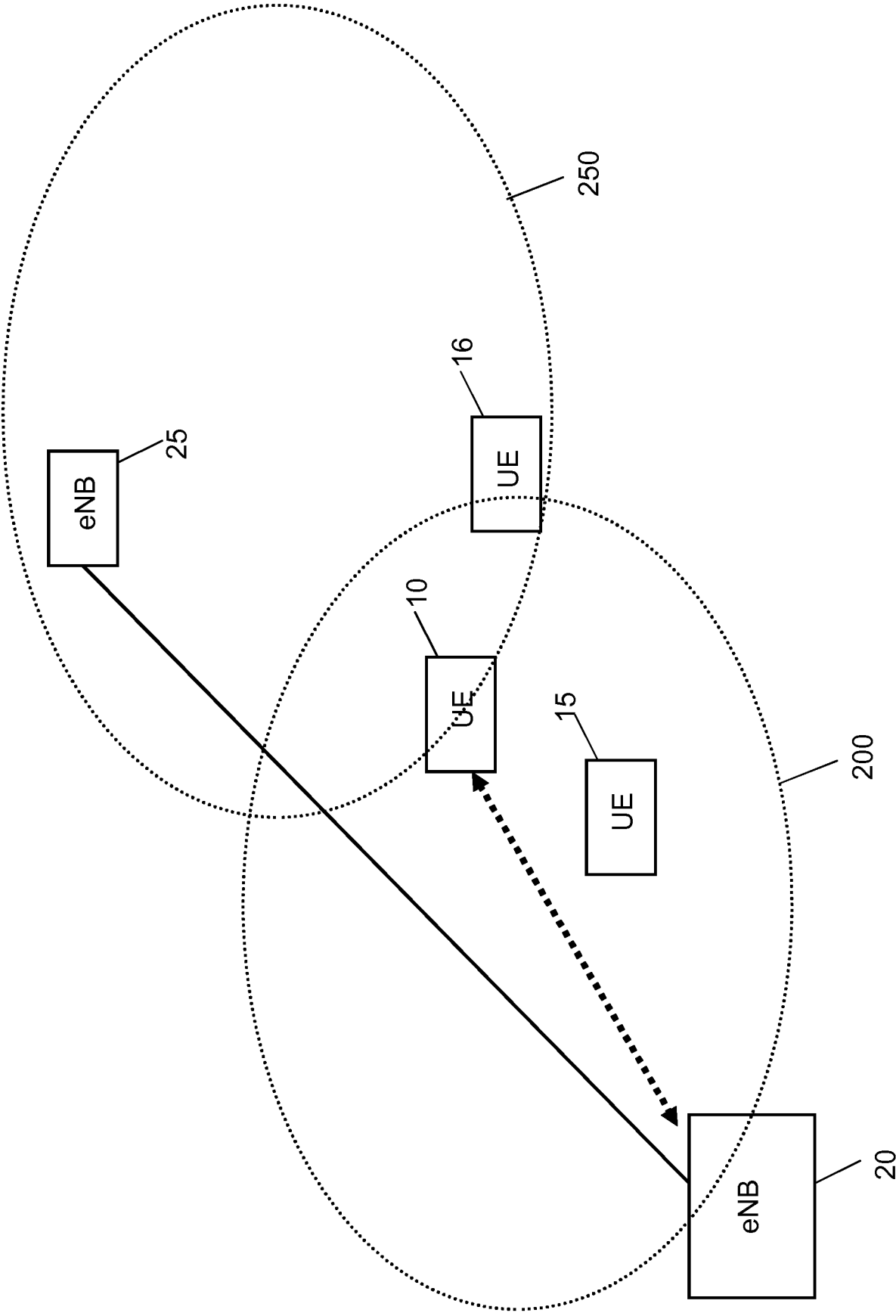


Fig. 1

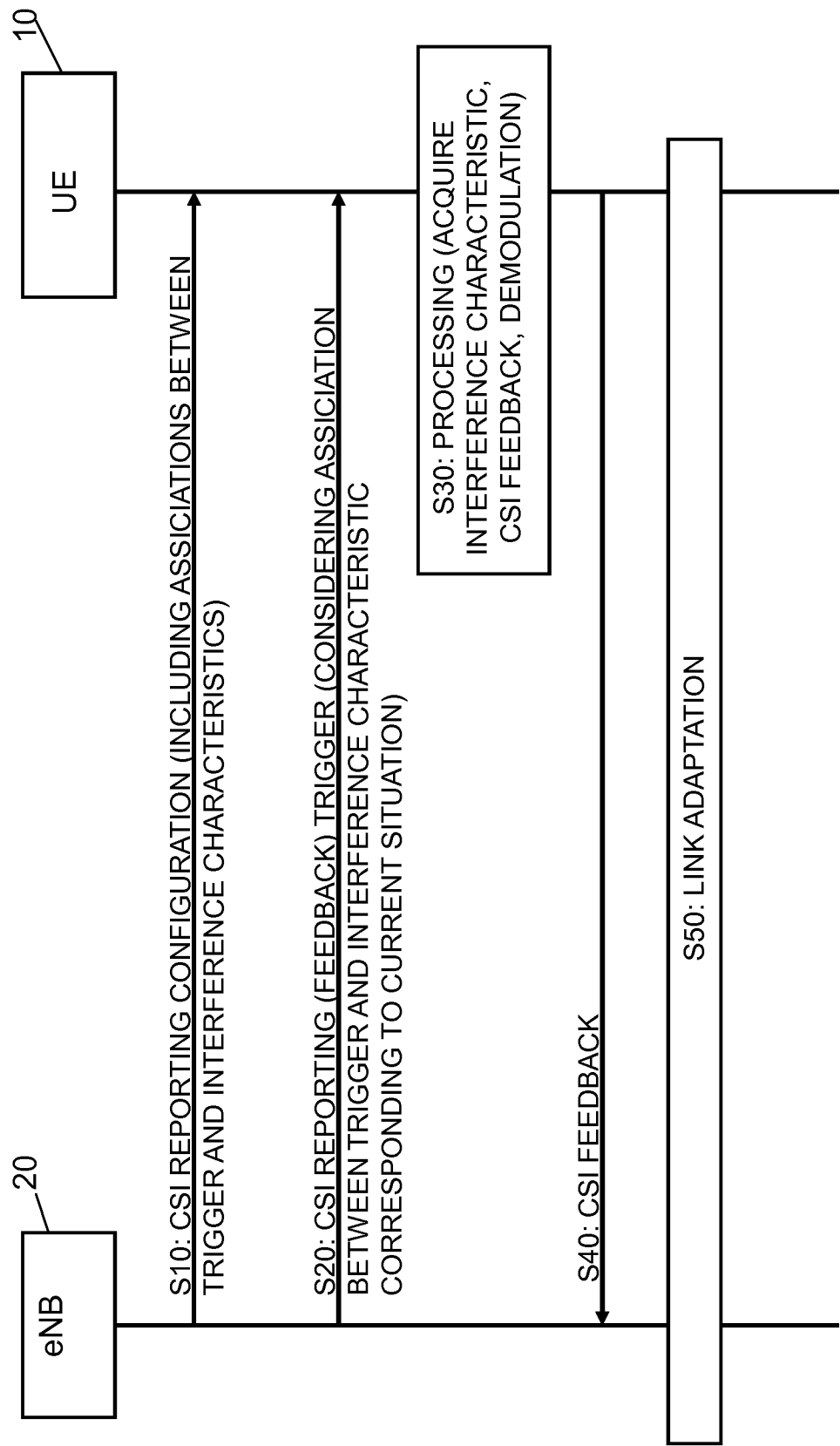


Fig. 2

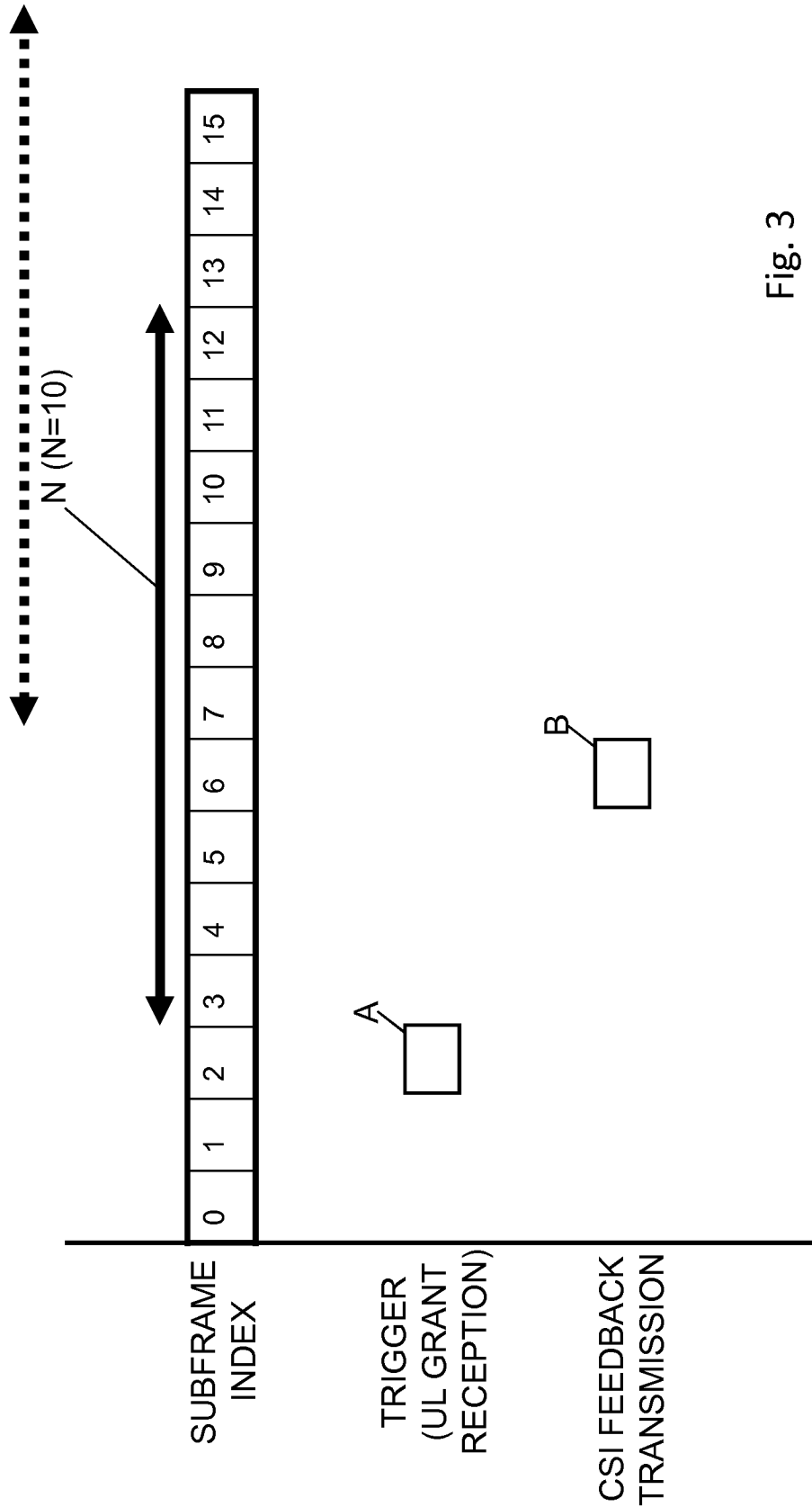


Fig. 3

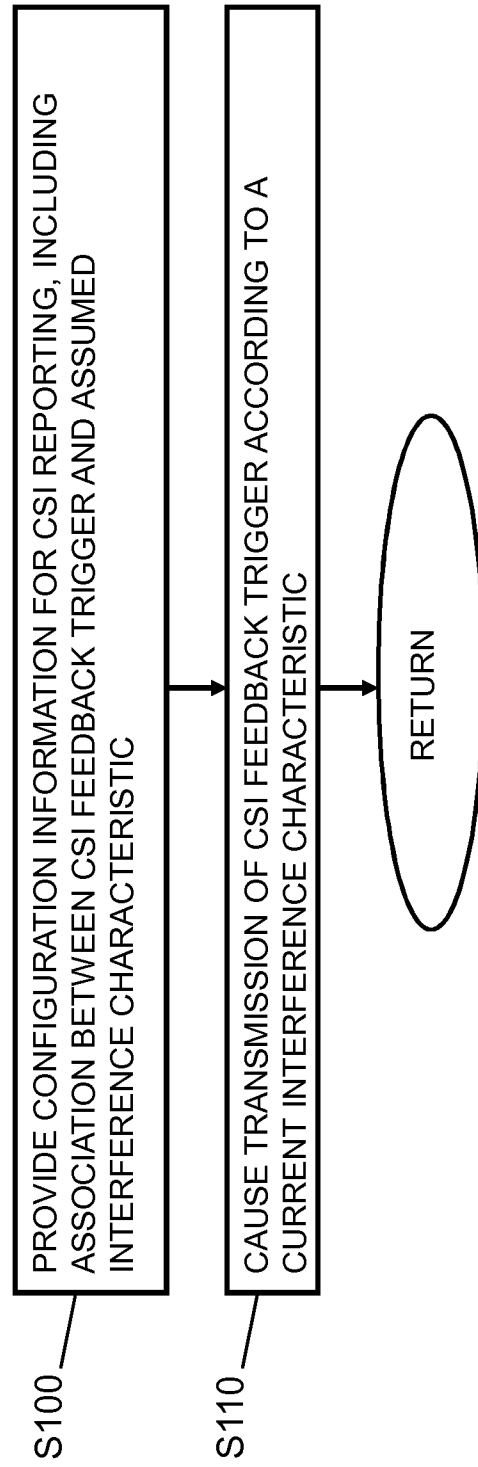


Fig. 4

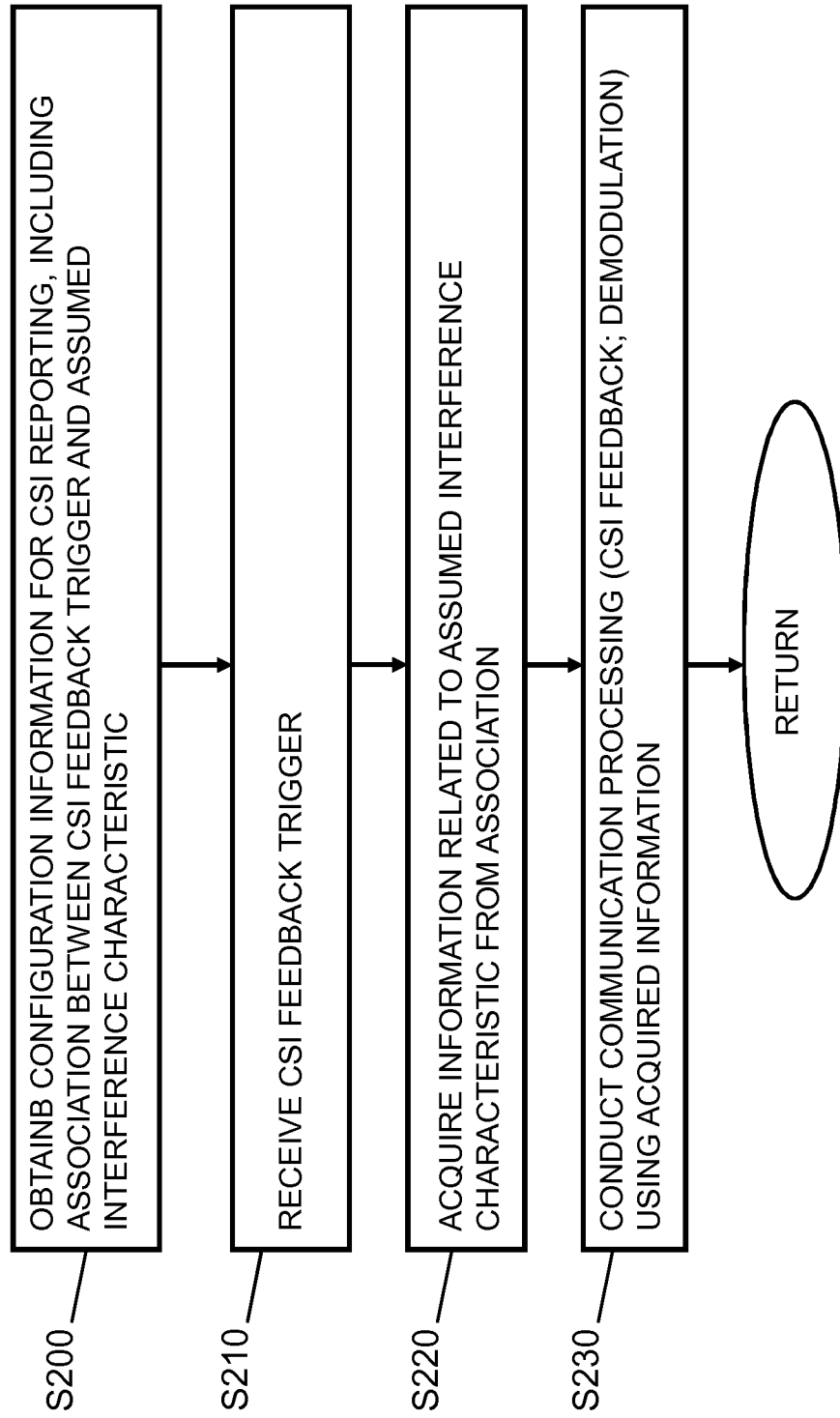


Fig. 5

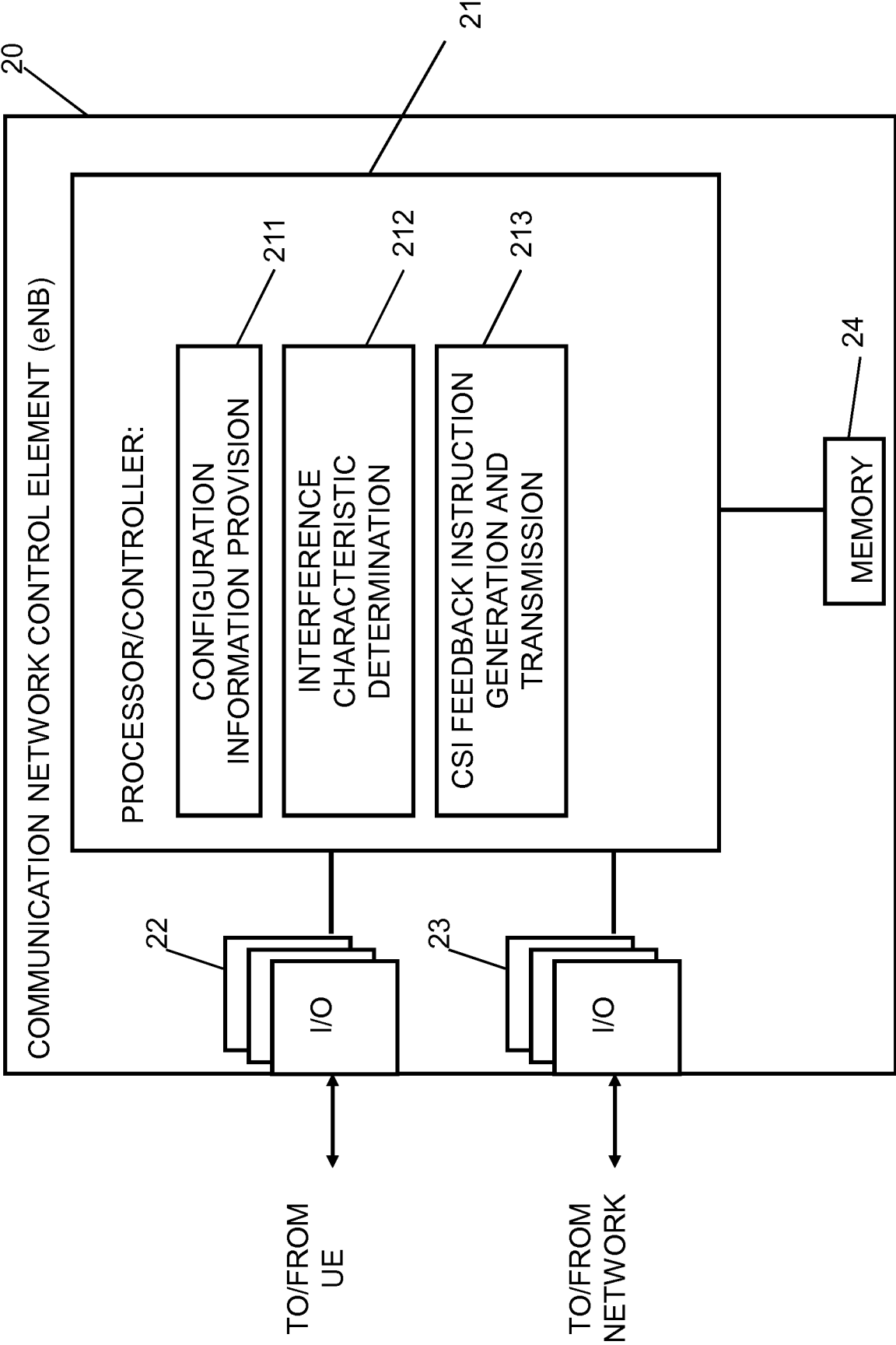


Fig. 6

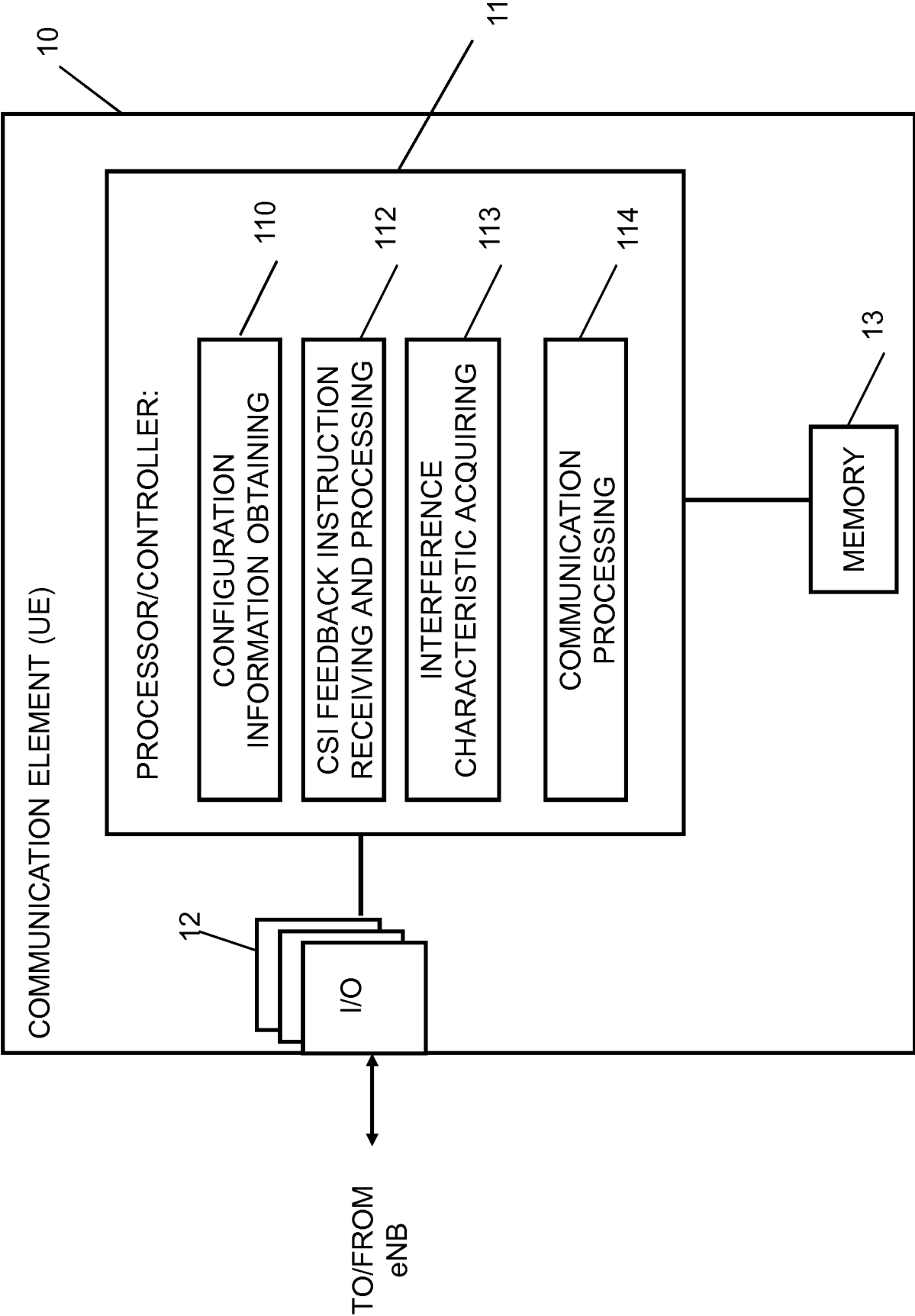


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/062407A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L1/00 H04W72/12
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)
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	ZTE: "Downlink control signaling for CoMP", 3GPP DRAFT; R1-122143 COMP_DL_CONTROL_SIGNALING, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Prague, Czech Republic; 20120521 - 20120525, 12 May 2012 (2012-05-12), XP050600411, [retrieved on 2012-05-12] pages 2-3, sections 3 and 3.1; figure 1 ----- -/--	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

2 February 2015

Date of mailing of the international search report

10/02/2015

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2014/062407

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NSN ET AL: "Network assistance for advanced receivers", 3GPP DRAFT; R1-140576, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Prague, Czech Republic; 20140210 - 20140214 9 February 2014 (2014-02-09), XP050736103, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2014-02-09] page 3, section 3.2 -----	1-20