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(54) Title: METHODS AND NETWORK NODES FOR CONTROLLING USAGE OF CACHING IN A TELECOMMUNICATIONS SYSTEM

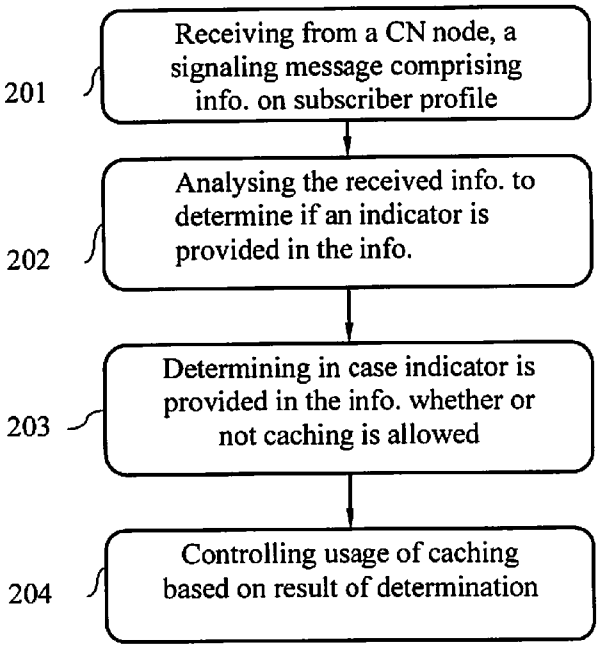

Fig. 2

(57) Abstract: The exemplary embodiments relate to a method for use in RAN node (700); a RAN node (700); a method for use in a CN node (800), and a CN node (800), for controlling usage of caching in the RAN on subscriber level. According to the present embodiments, the CN node (800) is configured to transmit to the RAN node (700) a signaling message including information on subscriber profile. The RAN node receives and analyses the message to determine whether an indicator is provided in the message. The RAN node (700) further determines in the case the indicator is present in the message whether or not caching in the RAN is allowed for use by the subscriber, and to control usage of caching in the RAN based on the result of the determination.

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METHODS AND NETWORK NODES FOR CONTROLLING USAGE OF CACHING IN A TELECOMMUNICATIONS SYSTEM

TECHNICAL FIELD

Embodiments herein generally relate to control of usage of caching in a telecommunications system and in particular to methods and network nodes of a radio access network respectively a core network for controlling usage of caching in the radio access network.

BACKGROUND

The following abbreviations are herewith defined, at least some of which are referred to within the following description.

3GPP	3rd Generation Partnership Project
BSC	Base Station Controller
CN	Core Network
CP	Control Plane
eNodeB	E-UTRAN NodeB
eNB	E-UTRAN NodeB
E-UTRAN	Evolved UTRAN
GSM	Global System for Mobile communications
GGSN	Gateway GPRS Support Node
HLR	Home Location Register
HSS	Home Subscriber System
HSPA	High Speed packet Access
IP	Internet Protocol
LTE	Long Term Evolution
MME	Mobility Management Entity
NB	Node B

PS	Packet Switched
PDN-GW	Packet Data Network - Gateway
RAN	Radio Access Network
RAT	Radio Access Type/Technology
RBS	Radio Base Station
RFSP	RAT/Frequency Selection Priority
RNC	Radio Network Controller
S1	Interface between eNB and CN
S1AP	S1 Application Protocol
S1-MME	Control Plane of S1
S1-U	User Plane of S1
SGSN	Serving GPRS Support Node
S-GW	Serving Gateway
SPID	Subscriber Profile ID
UE	User Equipment
UP	User Plane
UTRAN	Universal Terrestrial Radio Access Network
WCDMA	Wideband Code Division Multiple Access

Caching in mobile networks has been introduced to offload the network of the increasing amount of traffic e.g. Internet traffic in the networks because caching is based on that a large percentage of Internet traffic is repetitive. Therefore, the main principle is that copies of (data) content are moved closer to mobile users, for example in the difference parts or nodes of the RAN or in the CN or the like.

Benefits achieved with caching in mobile networks include:

a) Decrease of the cost of transport of the content in the mobile network. This is achieved "above the cache" as the cached content information in principle is transferred once in the transmission links above the cache i.e. from e.g. a media server to a CN node in the mobile network or if the cache is in the RAN the transmissions links between the RAN and the CN.

b) Improved Quality of Experience for the mobile end-users. This is mainly achieved with lower delays as the cached information can be returned faster to the

mobile users from the cache, compared to if the information would be retrieved all the way from the original location.

c) Provide new services such as content hosting and storage/backup for the operators. The mobile operators can sign agreements with the content providers that are based on that the mobile operator ensures that the content from a specific content provider is delivered in an efficient way to the mobile users or subscribers in the mobile operator's network.

Caching may also be used for the media distribution towards the mobile users i.e. instead of retrieving the downloadable media from the media server or other users the media may be retrieved from the cache. Fig. 1 shows how media information from one or more media servers 5, located in the Internet or at service providers, is pushed into the cache 6 located in a wireless communications network 1. Typically, the wireless communications network 1, also denoted the mobile network, includes the RAN 3 and the CN 4. The Internet is considered as external to the wireless communications network 1. Media information is retrieved or received normally from the Internet or any similar IP network. A UE 2 accessing the RAN 3 receives the media information directly from the cache 6 instead of from the media server(s). It is worth mentioning that caching may be used for almost any Internet content and that Fig. 1 is just an illustrating example based on media services.

As described earlier, the main principle of caching is that copies of (data) content are moved closer to mobile users. The RAN is thus a suitable place in the network whereto implement a cache or caches. But the complexity of the network architecture including different interfaces and functions such as legal of lawful interception, charging, mobility and policy control put some requirements on the

operator of the network. In other words, the operator should not just simply place a cache in the RAN and let the mobile users utilize it.

Legal or lawful interception (LI) concerns obtaining communications network data pursuant to lawful authority for the purpose of analysis or evidence. Such data generally consist of signalling or network management information or, in fewer instances, the content of the communications. One of the bases for LI is the interception of telecommunications by law enforcement agencies (LEAs), regulatory or administrative agencies, and intelligence services, in accordance with local law. Under some legal systems, implementations—particularly real-time access to content—may require due process and receiving proper authorization from competent authorities—an activity that was formerly known as "wiretapping" and has existed since the inception of electronic communications.

A problem with RAN caching and LI is that the user-plane traffic must be possible to intercept without any possible way to detect that the traffic is intercepted. A solution would be to define a new interface for interception purposed. It is however not considered as a feasible way forward to standardize a new RAN LI interface (e.g. from the RBS, RNC or BSC) for the intercept purposes due to costs and complexity involved in the standardization processes.

Charging in a mobile network is performed by the different core network and service network nodes. Charging can be divided into online charging and offline charging. A problem with RAN caching and charging is that the user-plane traffic is used for volume based, monthly bucket and content based charging e.g. charging rules depending on URL, and with the cache below core network i.e. in the RAN, it

is not possible today to trigger charging function for a given subscriber (or user) from the RAN nodes. One reason is that not all mobile systems allow the user subscriber identity to be available in the RAN for charging functions. This is also the case for LI functions i.e. it is not always possible to identify the end user or subscriber in the RAN.

SUMMARY

Objects according to the present embodiments are to alleviate at least the problems mentioned above.

An object is therefore to provide a method in a network node of a RAN and the network node thereof, for controlling usage of caching in the RAN on subscriber level without necessarily defining a new interface towards a RAN cache thereby enabling CN functions such as LI, charging, policy control etc. to be performed independently on the type of radio access technology used.

Another object according to present embodiments is to provide a method in a network node of a CN and the CN node thereof for enabling a network node in the RAN to control usage of caching in the RAN on subscriber level.

Thus, according to an aspect of exemplary embodiments, at least some of the above stated problems are solved by means of a method in a network node located in the RAN for controlling of usage of caching. The method comprises: receiving, from a CN node or from another RAN network node, a signalling message comprising information on subscriber profile that is dedicated to the subscriber; analysing the received information to determine if an indicator is provided in the information on subscribed profile; determining in the case the indicator is provided in the received information, whether or not caching in the

RAN is allowed for use by the subscriber and controlling usage of caching in the RAN based on the result of the determination.

According to another aspect of exemplary embodiments, at least some of the above stated problems are solved by means of a method in a network node located in the CN for enabling a network node in a RAN to control usage of caching in the RAN on subscriber level. The method comprising, assembling a signalling message comprising information on subscriber profile that is dedicated to the subscriber; including in the information on subscriber profile an indicator indicating whether or not caching in the RAN is allowed for use by the subscriber and transmitting the assembled message including the indicator to the RAN node for enabling the RAN node to determine whether or not caching in the RAN is allowed for use by the subscriber.

According to another aspect of exemplary embodiments, at least some of the above stated problems are solved by means of a network node of a RAN, for controlling usage of caching in the RAN, the network node comprises: a receiver circuit configured to receive, from a CN node or from a RAN node of the telecommunications system, a signalling message comprising information on subscriber profile dedicated to a subscriber; a processing circuit configured to analyse the received information on subscriber profile to determine if an indicator is provided in said information on subscriber profile for the subscriber; the processing circuit is further configured to determine, in the case the indicator is provided in the information on subscriber profile, whether or not caching in the RAN is to be allowed for use by the subscriber; and the processing circuit is configured to control usage of caching in the RAN based on the result of the determination.

According to another aspect of exemplary embodiments, at least some of the above stated problems are solved by means of a network node located in the CN, for enabling a network node in a RAN to control usage of caching in the RAN on subscriber level. The network node in the CN comprises: a processing circuit configured to assemble a signalling message comprising information on subscriber profile that is dedicated to a subscriber; the processing circuit is further configured to include in the information on subscriber profile an indicator indicating whether or not caching in the RAN is allowed for use by the subscriber. The network node in the CN further comprises a transmitter circuit configured to transmit the assembled message including the indicator to a RAN node for enabling the RAN node to determine whether or not caching in the RAN is allowed for use by the subscriber.

An advantage with the present embodiments is to allow the mobile operator to configure or control on a subscriber level whether caching in the RAN is allowed or not and by this enable triggering of CN functions such as LI, charging etc. for a given subscriber depending on if caching in the RAN is allowed or not.

Another advantage is to avoid defining a new interface and instead make use of already standardized interface(s) independently of the used RAT technology.

A further advantage is that it allows caching to be enabled on subscription level and the mobile operators may use this as an opportunity to include caching only on specific types of subscriptions for which for example an addition fee can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a basic network scenario wherein caching is implemented in a mobile network.

Figure 2 is a flowchart illustrating main method steps performed by a network node in a RAN according to the present embodiments.

Figure 3 is a flowchart illustrating main method steps performed by a network node in a CN according to the present embodiments.

Figure 4 illustrates a simplified LTE network scenario implementing the exemplary embodiments described herein.

Figure 5 illustrates a simplified UMTS/HSPA network scenario implementing the exemplary embodiments described herein.

Figure 6 illustrates a simplified network scenario comprising a plurality or RATs wherein embodiments herein maybe applied.

Figure 7 is a block diagram illustrating an exemplary RAN network node according to the present embodiments.

Figure 8 is a block diagram illustrating an exemplary CN network node according to the present embodiments.

DETAILED DESCRIPTION

Briefly described, exemplifying embodiments of network nodes and methods provided for controlling usage of caching in the RAN on subscriber level. Particularly, the network nodes include: a RAN network node, referred to below as RAN node, and CN network node referred to as CN node. The RAN node may be a radio network controller (RNC); a base station controller (BSC), a radio base station e.g. a RBS, an eNodeB or eNB, a NodeB, a donor base station or a RAN controller

node, depending on the RAT used. For example in UMTS/UTRAN/HSPA or GSM the RAN node maybe a RNC, a BSC or any suitable controller node located within the RAN. In LTE/E-UTRAN, the RAN node maybe a eNB or another RAN controller node as LTE/E-UTRAN does not use a RNC.

The CN node maybe a mobility management entity (MME), a serving gateway (S-GW), a serving general packet radio service support node (SGSN), a MSC, a home subscriber system (HSS) or a home location register (HLR). For example, in UMTS/UTRAN or GERAN or GSM or HSPA, the CN node may be a HLR/HSS or a SGSN or MSC whereas in LTE/E-UTRAN, the CN node maybe a HSS or a MME.

Before describing the different network scenarios implementing the present embodiments the main steps performed by a RAN node respectively a CN node are first described and illustrated.

Fig. 2 depicts the main method steps performed by RAN node in accordance with the present embodiments. As shown, the method comprises: receiving 201 by the RAN node from a CN node or from another RAN network node, a signalling message comprising information on subscriber profile that is dedicated to a subscriber; analysing 202 the received information to determine if an indicator is provided in the information on subscribed profile; determining 203 in the case the indicator is provided in the received information, whether or not caching in the RAN is allowed for use by the subscriber and controlling 204 usage of caching in the RAN based on the result of the determination.

Fig. 3 depicts the main method steps performed by a CN node for enabling a RAN node to control usage of caching in the RAN on subscriber level in accordance with the present embodiments. As shown, the method comprises: assembling 301

a signaling message comprising information on subscriber profile that is dedicated to the subscriber; including 302 in the information on subscriber profile an indicator indicating whether or not caching in the RAN is allowed for use by the subscriber and transmitting 303 the assembled message including the indicator to the RAN node for enabling the RAN node to determine whether or not caching in the RAN is allowed for use by the subscriber.

The information on subscriber profile is a subscriber profile identity (SPID). The SPID is also known as a RAT frequency selection priority (RFSP) index or subscribed RFSP. The SPID may be assigned to specific subscriptions and stored in one or several CN nodes. For example, if the SPID is stored in the HSS, it is called a subscribed RFSP index. The subscription is assigned or dedicated to a subscriber having a user equipment (UE). The signaling between the CN and the RAN is standardized. An example of usage of SPID in a radio base station is to map the received SPID value to a specific set of RAT/carrier that is used as dedicated priority information towards the UE. Another possible usage is as part of the radio resource management (RRM). RRM functions are concerned with the allocation and maintenance of radio communication paths, and are performed by the RAN. The RRM strategy in e.g. E-UTRAN/LTE may be based on user specific information.

The SPID reaches the RAN node as follows. When the UE having the subscription, attaches to the mobile network, the subscription context is downloaded to a CN node from another CN node and when the UE context is created in the RAN node, the SPID is signalled from the CN node to the RAN node. The SPID in accordance with the present embodiments is extended to further include an indicator indicating whether or not caching is allowed. This will help the RAN node in deciding which subscribers are allowed to use the cache.

As mentioned earlier, the RAN node, according to the present embodiments, determines if caching is allowed or not for the subscriber by checking/determining a value of the indicator, and if the value of the indicator indicates that caching in the RAN is allowed for the subscriber, the RAN node controls usage of caching by e.g. comparing a request for information received from the subscriber with a cache content provided in the RAN cache associated with the RAN node and if the requested information is in the cache, the RAN node allows the subscriber to retrieve the requested information from the cache. But if the value of the indicator indicates that caching in the RAN is not allowed for the subscriber, the RAN controls usage of caching by forwarding the subscriber's request for information to an intended server or the RAN node signals to the cache associated with the RAN node that caching in the RAN is not allowed for the subscriber. For example the SPID could indicate that for this subscriber: "100=usage of caching is to be allowed", "101=usage of caching is not to be allowed". So if the value 100 is indicated then a subscriber's request for information is compared to the cache content, and if the requested information is in the cache then it can be returned to the subscriber from the cache. But if the value 101 is indicated then the subscriber's request for information is instead of comparing to the cache content, forwarded to an intended server, for example an Internet or media server. Note that the embodiments are not restricted to the above values of 100 and 101. The values are design parameters.

Hence, the SPID is extended to have it as input to the cache logic and/or processing circuit in the RAN or RAN node as an indicator in deciding which subscribers' traffic is allowed to be cached.

This way it is possible to control RAN caching on subscription level to enable CN functions such as LI, charging, policy control etc. for a given subscriber depending on if caching in the RAN is allowed or not.

For example, if LI is activated in the CN or special charging is required for specific type of subscription of a specific subscriber for which for example an addition fee in the CN is required, SPID received at the RAN node from the CN node may indicate that RAN caching is not allowed for this subscriber to ensure that the CN functions work properly. Hence, an operator of the network may use this as an opportunity to include caching only on specific types of subscriptions for which for example an addition fee can be obtained..

It should be mentioned that in the prior art 3GPP architecture, functions that normally are executed in the mobile packet core network such as charging, LI, mobility, and policy control are based on that all the user-plane traffic is anchored in and passes a gateway e.g. the GGSN/P-GW in order to be able to execute its functions and as previously described there is no user subscriber identity in the RAN of some mobile systems e.g. the IMSI in case of LTE RAN, that could be used to identify the end user for charging or lawful intercept actions. But using the solution in accordance with the present embodiments enables these CN functions to function properly even in a mobile system that does not allow the user subscriber identity to be available in the RAN for such functions. Furthermore the method described above is achievable independently of the radio access technology (RAT) used.

The following sections describe in more details how SPID is transferred from the CN to the RAN for the different RATs.

Fig. 4 illustrates a simplified architecture for the E-UTRAN/LTE case when the SPID is used to indicate whether caching in the RAN is allowed or not. As previously described the SPID or subscribed RFSP index is transferred from HSS 401 to MME 402 where it is translated or converted to subscribed RFSP index in use. Even in other systems, the CN nodes translate or convert the SPID into an RFSP index in

use. For example, for UTRAN, the SGSN performs the translation and for GERAN, the MSC performs the translation as will be schematically shown in Fig. 6.

Referring back to Fig. 4, the MME 402 receives the SPID from the HSS 401 during the UE attach procedure and the SPID is stored in MME 402. At UE context setup the MME 402 forwards the SPID or the subscribed RFSP index to the RAN node eNB 404. It should be mentioned that for roaming subscribers/UEs MME 402 may remove or add SPID based on IMSI analysis. Fig. 4 also illustrates gateways 407 i.e. a packet data network gateway (PDN-GW) and a serving gateway (S-GW) that are connected to the Internet. A UE 406 within the coverage area of the E-UTRAN/RAN is also depicted.

In the E-UTRAN/LTE scenario, the following signaling messages include SPID: INITIAL CONTEXT SETUP REQUEST; UE CONTEXT MODIFICATION REQUEST; HANDOVER REQUIRED and HANDOVER REQUEST containing source eNB to target eNB transport container.

The INITIAL CONTEXT SETUP REQUEST message may contain the following information elements IEs: The Handover Restriction List IE, which may contain roaming, area or access restrictions; the UE Radio Capability IE; the subscriber profile ID for RAT/Frequency priority IE; the circuit switch fallback indicator IE and the SRVCC operation possible IE. The INITIAL CONTEXT SETUP REQUEST message shall contain the SPID for RAT/Frequency priority IE, if available in the MME which is the case in this scenario. The same applies for UE CONTEXT MODIFICATION REQUEST.

In the case of a handover of a UE from a source eNB to a target eNB, the SPID for RAT/Frequency priority IE is transferred over X2 from the source eNB to the target eNB. Hence, according to an embodiment and in case of a handover the RAN node e.g. the target eNB is configured to receive the SPID from the source RAN

node e.g. the source eNB in a signalling message including the SPID indicating whether or not caching in the target RAN node is allowed to be used by the handed-over UE.

Referring back to Fig. 4, the eNB 304 in possession of the SPID (or subscribed RFSP index in use) is configured to control usage of caching in the RAN. The cache 405 may be placed either in the eNB 404 or be connected to the eNB 404 or the cache 405 may be placed higher up in the RAN e.g. in (or connected to) a RAN controller node 403 as shown. In the scenario of Fig. 4, there are two sub-scenarios depending on if the signaling between the MME 402 and the eNB 404 traverses via the cache 405 or not. In the exemplary sub-scenarios the SPID value is considered received on a UE-specific signaling connection from the MME 402. The interface between the MME and the eNB is known as the S1-MME interface. Also, in the exemplary sub-scenarios, the S1-U interface i.e. the user plane between the eNB 404 and the serving gateway S-GW 407 may be configured to traverse via the cache 405.

Scenario 1: Cache (not shown) in the eNB 404.

In this scenario the eNB 404 analyses the received message comprising the SPID value to determine whether or not caching is allowed in order to control usage of caching i.e. to decide whether the UE 406 using the subscription is allowed to use the local cache in (or connected to) the eNB 404.

Scenario 2: Cache 405 higher up in the RAN e.g. in the RAN controller node 403:

In scenario 2 there are two sub-scenarios:

- Sub-scenario 2a: MME-eNB signaling interface S1-MME does not traverse via the cache.

In this sub-scenario, the eNB 304 uses the received SPID value to decide whether the UE 406 using the subscription should be allowed to use the cache higher up in the RAN.

If SPID indicates that caching is allowed, then the eNB 404 signals to the cache and indicates that caching is allowed. The S1-U interface i.e. the user plane between the eNB 404 and the S-GW 407 may pass through the cache 405. If the S1-U interface passes through the cache e.g. via configuration of the transport network, then it is enough that the eNB 404 signals to the cache 405 that caching is allowed.

If SPID indicates that caching is not allowed, then the eNB 404 ensures that caching is not used. One way to achieve this is that the eNB 404 doesn't link the S1-U interface to go via the cache 405. Another way is that the eNB 404 signals to the cache 405 that caching is not allowed for the subscriber or UE 406. The latter action is used in the cases when the S1-U interface traverses through the cache 405. A further approach is that, as previously described, the RAN node i.e. eNB 404 in this example, forwards the request for information received from the subscriber or UE 406 to an intended (Internet) server.

- Sub-scenario 2b: MME-eNB signaling interface S1-MME does traverse via the cache.

In this sub-scenario, the cache 405 may intercept the S1 application protocol (S1AP) signaling on the S1-MME interface and detects the SPID value indicated from the MME 402. The cache 405 in the RAN controller node 403 then uses the SPID value to decide whether the UE 406 using the subscription should be allowed to use the cache or not. Therefore the main difference towards sub-scenario 2a is that in this sub-scenario the eNB 404 doesn't need to signal the SPID value to the

cache 405. The eNB 404 is configured to take similar actions to ensure that S1-U interface traverses via the cache 405 (in case caching is allowed).

Fig. 5 illustrates a simplified architecture for the WCDMA/HSPA case when the SPID is used to indicate whether caching in the RAN is allowed or not. Fig. 5 shows a CN comprising a HSS 501 connected to a SGSN 502 which in turn is connected to a GGSN 507. The GGSN 507 is connected to the Internet. In the RAN or UTRAN, a RNC 503 is provided connected to a NodeB or NB 504. A UE 506 is also shown. Fig. 5 also shows a cache 505 being an integral part of the RNC although this is not necessary. In the following, four scenarios are described depending on where the cache is located in the RAN.

It should be mentioned that in WCDMA, the following signalling messages comprise SPID: COMMON ID; DIRECT TRANSFER; RELOCATION REQUEST, RELOCATION REQUIRED and RANAP ENHANCED RELOCATION INFORMATION REQUEST, all including source RNC to target RNC Transparent Container, which includes SPID.

At handover the SPID is transferred RAN to RAN with a transparent container. At cell reselection, i.e. the UE changes cell but the network has not 'prepared' the target RAN node, the CN node need to send a new SPID. A coordinated SPID coding is needed to get same UE behaviour regardless of how the UE arrived at the target cell.

Referring back to Fig. 5, the HSS 501 and the SGSN 502 are handling the SPID as normally and the new actions in accordance with exemplary embodiments are taken by the RNC 503 or NodeB or NB 504. In all the scenarios it is assumed that Iu-PS UP interface i.e. the user-plane interface between the RNC 503 and the SGSN 502 or the GGSN 507 traverses via the cache. It is further assumed that the UE 506, as previously described, is configured to send a request for information e.g. media

or data and the information may be provided as cache content for allowing the subscriber or UE 506 to retrieve it from the cache if the UE 506 is allowed to do so.

Scenario 1: Cache 505 in the RNC 503 (as shown in Fig. 5)

The RNC 503 is configured to receive from a CN node, being the SGSN 502 in this example, a signaling message including the SPID or RFSP index in use, and to analyse the SPID to determine if an indicator is provided in the SPID. If the indicator is present, the RNC 503 determines whether or not caching in the RAN is allowed i.e. to determine whether the UE 506 using the subscription is allowed to use the local cache in the RNC 503. No specific actions are needed in this case for the Iu-PS UP interface as both the cache and the interface are in the same node i.e. in the RNC 503.

Scenario 2: Cache (not shown) higher up in the RAN i.e. above the RNC 503 but below/before the CN.

The actions of the RNC 503 are very similar to the actions taken by the eNB 404 described previously in relation to Fig. 4 i.e. "Scenario 2: Cache 405 higher up in the RAN e.g. in the RAN controller node 403". The S1-MME interface is in this scenario called the Iu-PS interface also known as the Iu-PC CP to indicate that it is the control plane part of this interface. The two sub-scenarios 2a and 2b described earlier in relation to Fig. 4 are also applicable here.

Scenario 3: Cache (not shown) between the RNC 503 and the NB or NodeB 504.

In this case the RNC 503 and the cache do not need to have a new signaling interface. When the RNC 503 receives the SPID value in the signaling message, from the SGSN 502, it is forwarded to the cache. The cache (or the RNC) may use the received value to decide whether caching is allowed or not for the UE 506

associated with the signaling connection. Note that since the cache is in the RAN it is herein also considered to be a RAN node.

Scenario 4: Cache (not shown) in the NB or NodeB 504.

When the RNC 503 receives (in the signaling message) the SPID value from the SGSN 503, it is forwarded to the NB 504. The NB 504 is then configured to use the received SPID value to determine/decide whether caching is allowed or not for the UE associated with the signaling connection.

The above scenarios 3 and 4 do need extra measures as normally caching below RNC is not possible due to air interface ciphering being terminated in the RNC. However, if the ciphering termination point would be moved between the RNC and the NodeB, or even into the NodeB, then these scenarios are also valid ones.

Fig. 6 illustrates a network scenario, including a plurality of RANs of different RATs i.e. E-UTRAN; UTRAN and GERAN connected respectively to CN nodes MME, SGSN and MSC, wherein the exemplary embodiments of the present invention may be implemented. It should be noted caching does not apply for circuit-switched services (e.g. voice). But, the MSC being a circuit switched (e.g. voice) node may be configured to send the SPID including the indicator, to a RAN node e.g. to a GERAN node or to a UTRAN node or to a E-UTRAN node and the RAN node uses said SPID for controlling usage of caching in the RAN for packet-switched services/traffic. The handling of SPID in different nodes is also shown in a simplified scenario. For example, as previously described in conjunction to Fig. 4 (E-UTRAN/LTE scenario), the HSS and the MME handle SPID in the CN and the SPID is signalled from the MME to the RAN node of the E-UTRAN. As previously described the SPID stored in the HSS is called subscribed RFSP index and it is

subsequently translated in the MME; the SGSN and the MSC respectively. This is shown in Fig. 6.

Similarly, for UTRAN/WCDMA/HSPA, the HSS and SGSN/MSC handle SPID which is signalled from the SGSN/MSC to the RAN node of the UTRAN. For GERAN, the SPID is handled by the HSS and SGSN/MSC and is subsequently signalled to the RAN node in the GERAN.

In case of handover of the UE (or subscriber (not shown) from a source RAN to a target RAN, the SPID or RFSP index is transferred in appropriate signalling message(s) between the RANs, as shown in Fig. 6. For roaming subscribers, the MME may remove or add SPID based on the IMSI analysis.

The above described exemplary embodiments are not restricted to LTE and WCDMA based systems, they are equally applicable for GPRS/EDGE and GSM systems. Caching in the RAN for GPRS/EDGE and GSM systems need extra measures as normally caching below SGSN (for GPRS/EDGE and GSM) is not possible due to air interface ciphering being terminated in the SGSN. However, if the ciphering termination point would be moved between the SGSN and the BSC, or even into the BSC or into the BTS, then these scenarios are also valid ones.

In GPRS/EDGE, the signalling messages that comprise SPID are: DL-UNITDATA (for every new DL-packet); CREATE-BSS-PFC (when bearer is established); Handover from GERAN: PS-HANDOVER-REQUIRED (in the transparent RAN container); Handover to GERAN: PS-HANDOVER-REQUEST as a specific IE (i.e. the transparent RAN container in the PS-HANDOVER-REQUEST message does not contain the SPID).

In GSM, the following signalling messages comprise SPID: ASSIGNMENT REQUEST; COMMON ID, Handover from GERAN: HANDOVER-REQUIRED (containing Source

RNC to target RNC transparent information. Only applicable to handover to UTRAN); Handover to GERAN: HANDOVER-REQUEST as a specific BSSAP IE (i.e. the transparent RAN container in the HANDOVER-REQUEST message does not contain the SPID)

Referring to Fig. 7, there is illustrated a block diagram of exemplary components of a RAN node 700 in accordance with the previously described embodiments. The RAN node 700 may a RNC, a NodeB (or NB), a RAN controller node, a eNB, a RBS, a BSC, depending on the radio access technology to which the mobile network belongs as previously described. As illustrated, the RAN node 700 may comprise one or more antennas connected to a receiver circuit (RX) 701 and a transmitter circuit (TX) 702. RX 701 and TX 702 are not necessarily separate circuits i.e. they could be integrated into a single transceiver circuit. The RAN node 700 further comprises a processing circuit 704, a memory circuit/unit 703 that may be part of the processing unit 704 or be a separate unit. The TX and RX are shown connected to the processing circuit 704. It should be noted that the RAN node 700 may comprise additional circuits or modules not shown in Fig. 7 such as for example interface(s) X2, S1 etc.

The receiver circuit 701 is configured to receive from a CN node or from another RAN, a signaling message comprising information on subscriber profile dedicated or assigned for/to a subscriber. The information on subscriber profile is the SPID or a subscribed RFSP index in use as previously described.

The processing circuit 704 is then configured to analyse the received information to determine if an indicator is provided in the information. The processing circuit 704 is further configured to determine, in the case the indicator is provided in the information whether or not caching in the RAN is to be allowed for use by the

subscriber and the processing circuit 704 is further configured to control usage of caching in the RAN based on the result of the determination. The processing circuit 704 is configured to determine a value of the indicator and if the value indicates that caching is allowed in the RAN, the processing circuit is configured to control usage of caching by comparing a request for information received from the subscriber (or UE) with a cache content provided in the cache associated with the RAN node 700. If the requested information is in the cache, the processing circuit allows the subscriber to retrieve the requested information from the cache.

If the value of the indicator indicates that caching in the RAN is not allowed for the subscriber, the processing circuit 704 is configured to control usage of caching by forwarding e.g. via the transmitter circuit 702 a request for information received from the subscriber to an intended server or by signaling to the cache associated with the RAN node 700 that caching in the RAN is not allowed for the subscriber. As previously describer, the cache may be placed in the RAN node 700 or be connected to the RAN node or the cache may be located in another RAN node connected to the RAN node 700. The cache may also be placed between RAN nodes and connected to the RAN nodes.

Referring to Fig. 8 there is illustrated a block diagram of exemplary components of a CN 800 in accordance with the previously described embodiments. The CN node 800 may be a MME, a SGSN, a MSC, a HSS, or a HLR depending on the radio access technology to which the mobile network belongs as previously described. As illustrated, the CN node 800 comprises a receiver circuit (RX) and a transmitter circuit (TX) 802 shown being part of an interface. A plurality of interfaces (S1, A, Iu, Gb etc.) may be provided although not shown. The CN node 800 further comprises a processing circuit 804, a memory circuit/unit 803 that may be part of the processing unit 804 or be a separate unit. The CN node 800 may comprise additional components/circuits.

According to the present embodiments, the processing circuit 804 is configured to assemble a signaling message comprising information on subscriber profile that is dedicated to a subscriber; the processing circuit 804 is further configured to include in the information on subscriber profile an indicator indicating whether or not caching in the RAN is allowed for use by the subscriber. The transmitter circuit 802 is configured to transmit the assembled message including the indicator to a RAN node 700 for enabling the RAN node to determine whether or not caching in the RAN is allowed for use by the subscriber.

Additional details concerning the functions of the RAN node and CN node have already been described and are not unnecessarily repeated.

The present invention and its embodiments can be realised in many ways. For example, an embodiment includes a computer-readable medium having instructions stored thereon that are executable by a computer system located in a RAN node for controlling usage of caching in the RAN. The instructions executable by the computing system and stored on the computer-readable medium perform the method steps of the as set forth in the claims. Another embodiment includes a computer-readable medium having instructions stored thereon that are executable by a computer system located in a CN node for enabling a RAN to control usage of caching in the RAN. The instructions executable by the computing system and stored on the computer-readable medium perform the method steps of the as set forth in the claims.

When using the formulation "comprise" or "comprising" it is to be interpreted as non-limiting, i.e. meaning "consist at least of". The term "configured to" may be equally exchangeable with being "adapted to" and is considered to have the same meaning. Various alternatives, modifications and equivalents may be used.

Therefore, the above embodiments are not to be taken as limiting the scope of the present invention, which is defined by the appending claims.

CLAIMS

1. A method for use in a network node (700) of a radio access network, RAN, of a telecommunications system, for controlling usage of caching in the RAN, the method comprising:
- receiving (201), from a core network, CN, node (800) or from a RAN network node of the telecommunications system, a signalling message comprising information on subscriber profile dedicated/assigned for/to a subscriber;
- analysing (202) the received information on subscriber profile to determine if an indicator is provided in said information on subscriber profile;
- determining (203), in the case the indicator is provided in the information on subscriber profile, whether or not caching in the RAN is to be allowed for use by the subscriber; and
- controlling (204) usage of caching in the RAN based on the result of said determining.

2. The method according to claim 1 wherein said determining (203) comprising determining a value of the indicator, and if the value of the indicator indicates that caching in the RAN is allowed for the subscriber, said controlling (204) comprising: comparing a request for information received from the subscriber with a cache content provided in a cache associated with the network node (700) and if the requested information is in the cache, allowing the subscriber to retrieve the requested information from the cache.

3. The method according to claim 1 wherein said determining (203) comprising determining a value of the indicator, and if the value of the indicator indicates that caching in the RAN is not allowed for the subscriber, said controlling (204)

comprising: forwarding a request for information received from the subscriber to an intended server or signalling to a cache associated with the network node (700) that caching in the RAN is not allowed for the subscriber.

4. The method according to anyone of claims 1-3 wherein said receiving (201), the information on subscriber profile is a subscriber profile identity, SPID, or a subscribed radio access technology frequency selection priority, RFSP, index in use.

5. A network node (700) of a radio access network, RAN, of a telecommunications system, for controlling usage of caching in the RAN, the network node (700) comprises:

- a receiver circuit (701) configured to receive, from a core network, CN, node (800) or from a RAN network node of the telecommunications system, a signalling message comprising information on subscriber profile dedicated/assigned for/to a subscriber;
- a processing circuit (704) configured to analyse the received information on subscriber profile to determine if an indicator is provided in said information on subscriber profile for the subscriber;
- the processing circuit (704) is further configured to determine, in the case the indicator is provided in the information on subscriber profile, whether or not caching in the RAN is to be allowed for use by the subscriber; and
- the processing circuit (704) is configured to control usage of caching in the RAN based on the result of the determination.

6. The network node (700) according to claim 5 wherein the processing circuit (704) is configured to determine a value of the indicator, and if the value of the indicator indicates that caching in the RAN is allowed for the subscriber, the

processing unit (704) is configured to control usage of caching by comparing a request for information received from the subscriber with a cache content provided in a cache associated with the network node (700) and if the requested information is in the cache, the processing unit (704) is configured to allow the subscriber to retrieve the requested information from the cache.

7. The network node (700) according to claim 5 wherein the processing circuit (704) is configured to determine a value of the indicator, and if the value of the indicator indicates that caching in the RAN is not allowed for the subscriber, the processing unit (704) is configured to control usage of caching by forwarding, via a transmitter circuit (702) of the network node (700), a request for information received from the subscriber to an intended server or by signalling to a cache associated with the network node (700) that caching in the RAN is not allowed for the subscriber.

8. The network node (700) according to anyone of claims 5-7 wherein the information on subscriber profile is a subscriber profile identity, SPID, or a subscribed radio access technology frequency selection priority, RFSP, index in use.

9. The network node (200) according to anyone of claims 5-8 is a radio base station such as a NodeB or NB or a eNB or the network node is a RAN controller node such as a RNC or base station controller, BSC.

10. A method in a network node (800) of a core network, CN, of a telecommunications system for enabling a network node (700) in a radio access network, RAN, to control usage of caching in the RAN on subscriber level, the method comprising,

- assembling (301) a signaling message comprising information on subscriber profile that is dedicated/assigned to/for a subscriber;

- including (302) in the information on subscriber profile an indicator indicating whether or not caching in the RAN is allowed for use by the subscriber, and

- transmitting (303) the assembled message including the indicator to the network node in the RAN (700) for enabling the network node in the RAN (700) to determine whether or not caching in the RAN is allowed for use by the subscriber.

11. A network node (800) of a core network, CN, of a telecommunications system, for enabling a network node (700) in a radio access network, RAN, to control usage of caching in the RAN on subscriber level, the network node (800) of the (800) comprises:

- a processing circuit (804) configured to assemble a signaling message comprising information on subscriber profile that is dedicated/assigned to/for a subscriber,

- the processing circuit (804) is further configured to include in the information on subscriber profile an indicator indicating whether or not caching in the RAN is allowed for use by the subscriber; and

- a transmitter circuit (804) configured to transmit the assembled message including the indicator to the network node in the RAN (700) for enabling the network node in the RAN (700) to determine whether or not caching in the RAN is allowed for use by the subscriber.

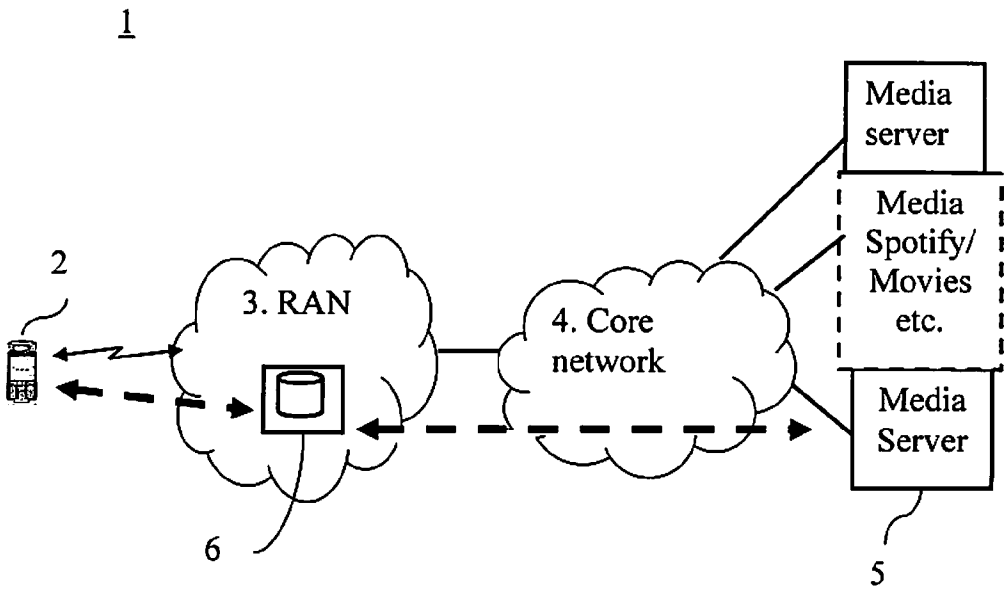


Fig. 1 (Prior art)

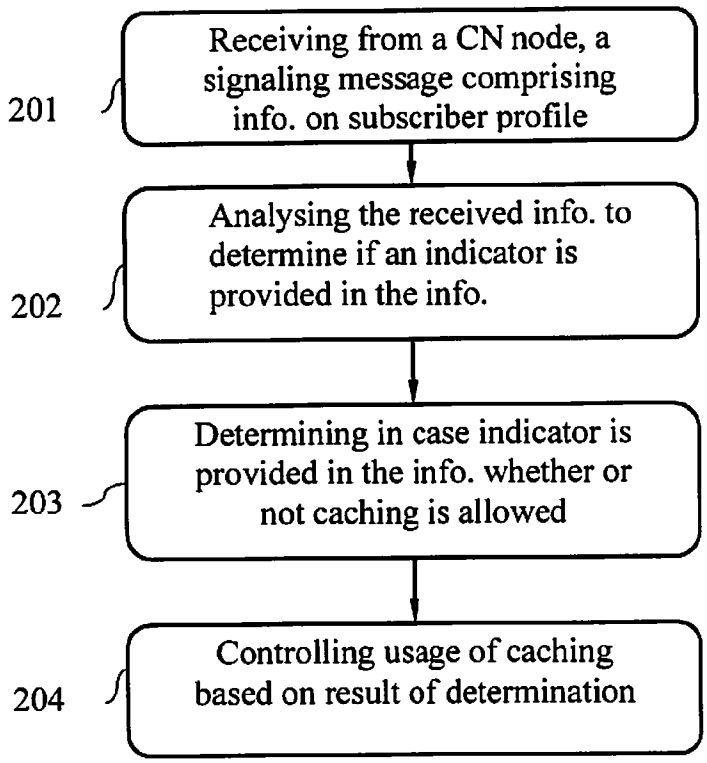

201
Receiving from a CN node, a signaling message comprising info. on subscriber profile
202
Analysing the received info. to determine if an indicator is provided in the info.
203
Determining in case indicator is provided in the info. whether or not caching is allowed
204
Controlling usage of caching based on result of determination

Fig. 2

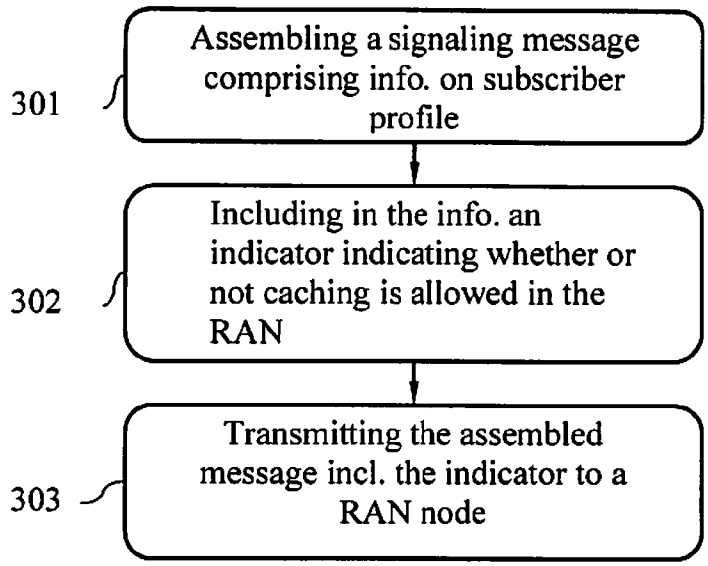
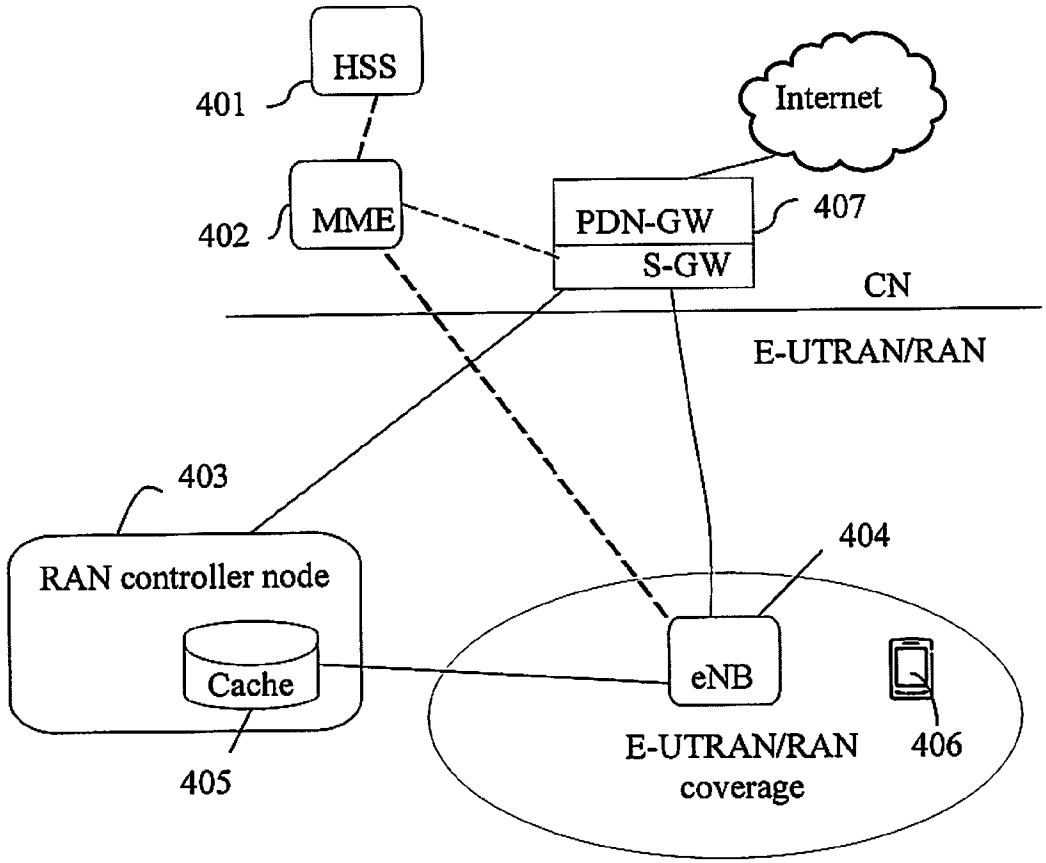
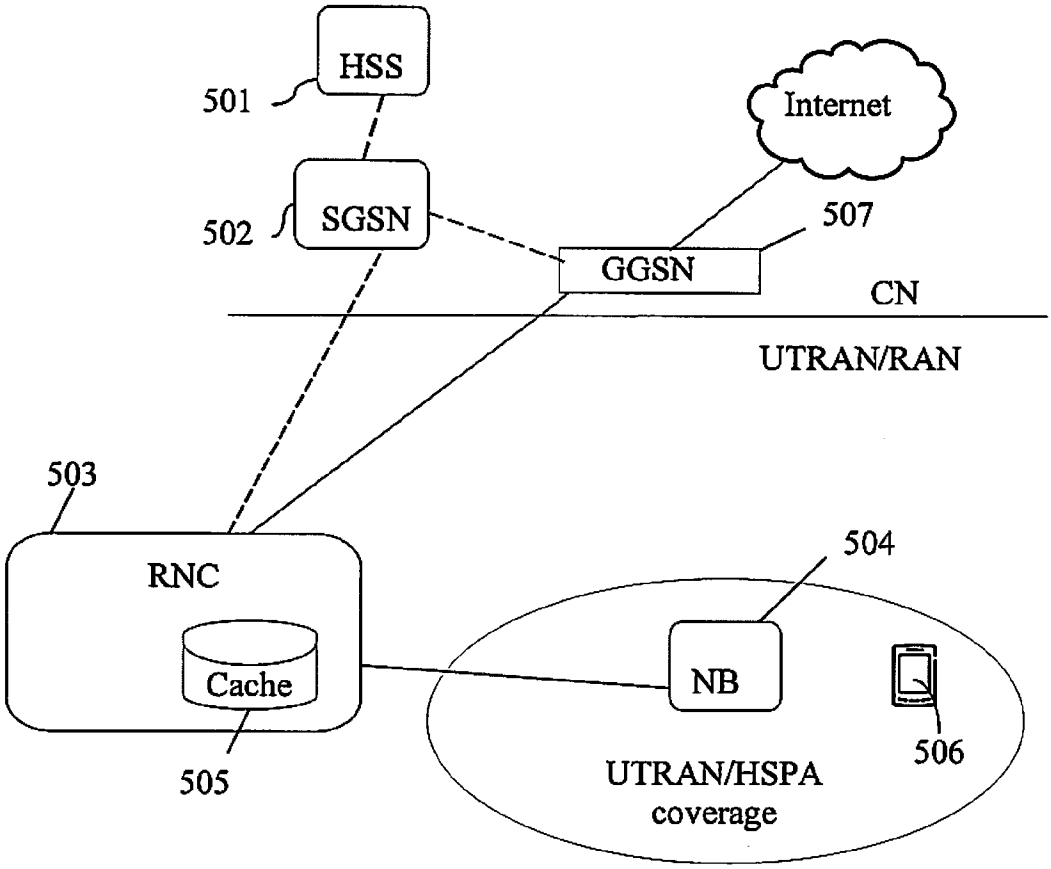

301
Assembling a signaling message comprising info. on subscriber profile
302
Including in the info. an indicator indicating whether or not caching is allowed in the RAN
303
Transmitting the assembled message incl. the indicator to a RAN node

Fig. 3



E-UTRAN/LTE scenario

Fig. 4



UTRAN/WCDMA/HSPA scenario

Fig. 5

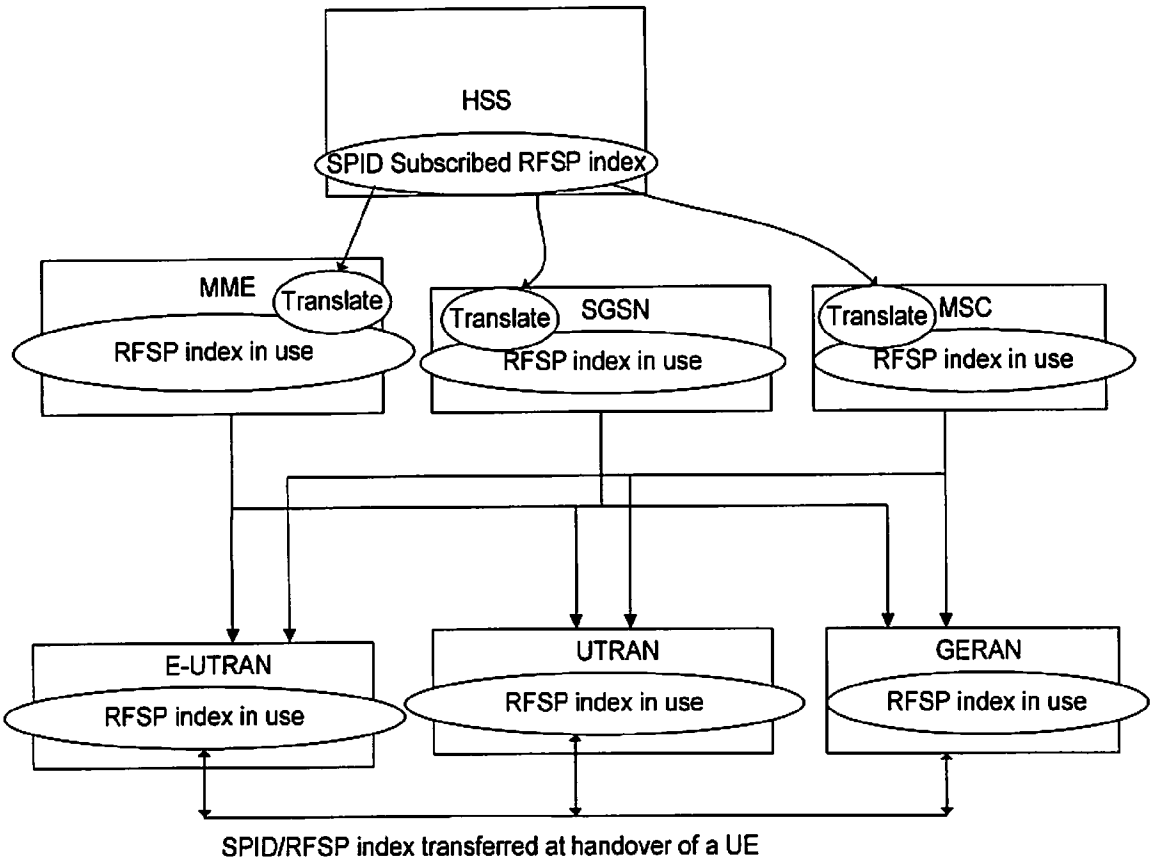

HSS
SPID Subscribed RFSP index
MME
Translate
RFSP index in use
Translate
SGSN
RFSP index in use
Translate
MSC
RFSP index in use
E-UTRAN
RFSP index in use
UTRAN
RFSP index in use
GERAN
RFSP index in use
SPID/RFSP index transferred at handover of a UE

Fig. 6

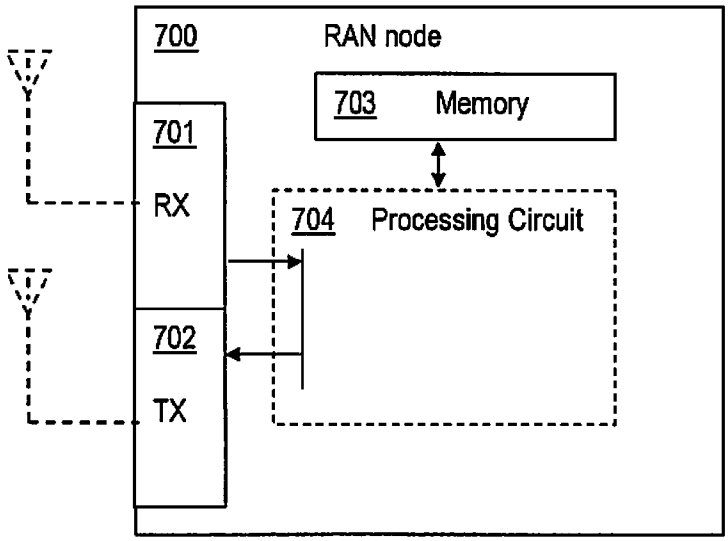


Fig. 7

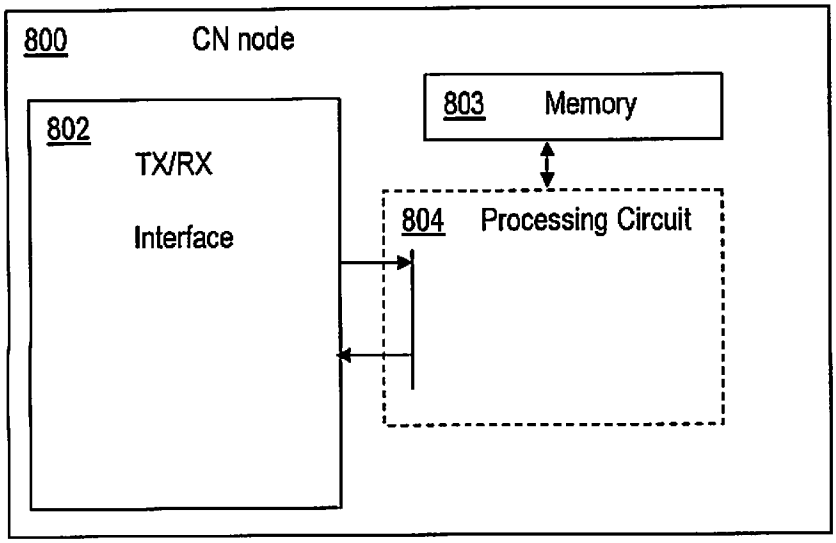

800
CN node
803
Memory
802
TX/RX
Interface
804
Processing Circuit

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2011/051127

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W28/14
ADD. H04W88/08 H04W88/12

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

B. FIELDS SEARCHED

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/034089 A1 (KOVVALI SURYA KUMAR [US] ET AL) 11 February 2010 (2010-02-11) abstract paragraph [0016] - paragraph [0017] paragraph [0040] - paragraph [0050] paragraph [0056] - paragraph [0061] -----	1-11
X	EP 1 928 154 A1 (FUJITSU LTD [JP]) 4 June 2008 (2008-06-04) abstract paragraph [0004] - paragraph [0012] paragraph [0015] - paragraph [0016] paragraph [0021] - paragraph [0035] paragraph [0042] - paragraph [0049] paragraph [0075] - paragraph [0082] paragraph [0089] ----- -/--	1-11

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

[X] 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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	Date of mailing of the international search report
9 May 2012	24/05/2012

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2011/051127

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 662 751 A1 (FUJITSU LTD [JP]) 31 May 2006 (2006-05-31) abstract paragraph [0036] - paragraph [0056] figure 9 -----	1-11
A	WO 01/43390 A2 (MARKPORT LTD [IE]; CORRIGAN LOUIS [IE]; DOYLE JOHN [IE]; HARTE ROBERT) 14 June 2001 (2001-06-14) abstract page 3, line 3 - line 14 page 7, line 1 - page 8, line 13 page 16, line 15 - line 21 page 17, line 26 - page 19, line 29 page 24, line 1 - line 30 -----	1-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/SE2011/051127

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		US 2002187775 A1	12-12-2002
		WO 0143390 A2	14-06-2001