



- (51) **International Patent Classification:**
H04W 28/00 (2009.01)
- (21) **International Application Number:**
PCT/EP2012/068468
- (22) **International Filing Date:**
19 September 2012 (19.09.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
11007608.0 19 September 2011 (19.09.2011) EP
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- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States (unless otherwise indicated, for every kind of regional protection available):** ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) **Title:** METHOD AND SYSTEM FOR ADMISSION CONTROL OF A TRAFFIC FLOW OF A USER EQUIPMENT

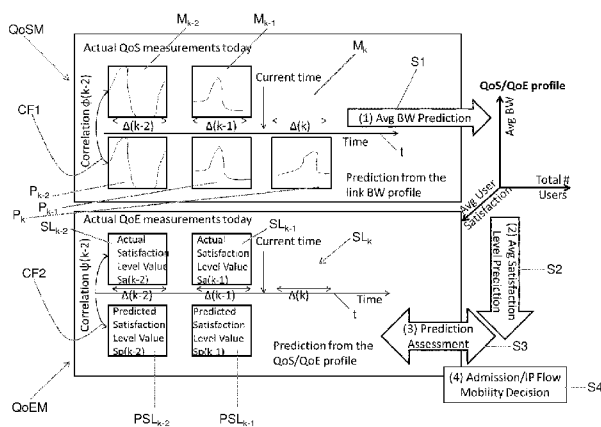


Figure 3

(57) **Abstract:** A method for admission control of at least one traffic flow of a user equipment from one cell of a first mobile communication network to another cell of a second mobile communication network, preferably from a cell of a macrocell network to a cell of a femtocell network, characterized by the steps of a) predicting a future network/service quality level based on past network/service quality levels of at least one of the networks, b) predicting a future user experience quality level based on the predicted network quality level and/or past user experience quality levels, c) determining an admission control policy based on the predicted future network/service quality level and the predicted future user experience quality level, to increase the future user experience quality level, Applying the determined admission control policy for the at least one traffic flow in at least one network.

METHOD AND SYSTEM FOR ADMISSION CONTROL OF A TRAFFIC FLOW OF A USER EQUIPMENT

5 The present invention relates to a method for admission control of at least one traffic flow of a user equipment from one cell of a first mobile communication network to another cell of a second mobile communication network, preferably from a cell of a macrocell network to a cell of a femtocell network.

10 The present invention further relates to a system for admission control of at least one traffic flow of a user equipment from one cell of a first mobile communication network to another cell of a second mobile communication network, preferably from a cell of a macrocell network to a cell of a femtocell network.

15 Although applicable in general to networks the present invention will be described with regard to a femtocell network and a macrocell network.

Femtocells are in general small, low-power cellular base stations which are typically designed to be used in a home or in SOHO (Small Offices/Home Offices). Femtocells are usually connected with a fixed broadband connection to a mobile operator's core network. For a mobile operator, femtocell deployments allow improvements in both coverage and capacity especially indoors. However, femtocells would become less attractive if the fixed broadband connection cannot keep up with the quality of service that a cellular or macrocell connection should provide. If a potential number of users simultaneously connect to a femtocell access point or generally speaking to a set of different femtocell access points, for example in a residential area, the communication path in the backhaul, for example to the same digital subscriber line access multiplexer DSLAM, to the home evolved node B gateway or other relevant potential node is congested or is about to get congested, the performance of the connection via the femtocell decreases.

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Therefore, as the number of femto access points and the number of users connected to these femto access points increase, for example in a residential area or the like and as these users using the femtocell access points not only use one

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device like a smartphone but also laptops with cellular modems or the like resulting in multiple bandwidth-intensive applications being simultaneously delivered, a congestion at the digital subscriber line access multiplexers DSLAM or other corresponding nodes occurs. This congestion degrades quality of service and impacts the quality of experience of the users. Therefore, the quality of mobile services provided at the femto access points depends not only on the radio link quality from user equipment to femto access points but also on the congestion level on the backhaul link from the femto access point.

To solve this problem a simple overprovisioning of the backhaul capacity on busiest sites results in high costs for resource-overprovisioning particularly in developing markets where wireless based communication is much more less expensive than cable-based solutions. Since providing resources is based on service level agreements with internet service providers and since new service level agreements are not updated frequently users may perceive poor quality of service until more resources are provided.

It is therefore an objective of the present invention to provide a method and a system which avoid congestion in mobile network deployments.

It is a further objective of the present invention to provide a method and a system which ensure a certain quality of service level in mobile network deployments.

It is an even further objective of the present invention to provide a method and a system which is more flexible with regard to handovers between different cells of mobile networks.

The aforementioned objectives are accomplished by a method of claim 1 and a system of claim 16.

According to claim 1 a method for admission control of at least one traffic flow of a user equipment from one cell of a first mobile communication network to another cell of a second mobile communication network, preferably from a cell of a macrocell network to a cell of a femtocell network is provided.

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According to claim 1 the method is characterized by the steps of

- a) Predicting a future network/service quality level based on past network/service quality levels of at least one of the networks,
- b) Predicting a future user experience quality level based on the predicted network quality level and/or past user experience quality levels,
- c) Determining an admission control policy based on the predicted future network/service quality level and the predicted future user experience quality level, to increase the future user experience quality level,
- d) Applying the determined admission control policy for the at least one traffic flow in at least one network.

According to claim 16 a method for admission control of at least one traffic flow of a user equipment from one cell of a first mobile communication network to another cell of a second mobile communication network, preferably from a cell of a macrocell network to a cell of a femtocell network, preferably for performing with a method according to one of the claim 1-15..

According to claim 16 the system is characterized by a quality mapper entity configured to be operable to predict a future network/service quality level based on past network quality/service levels of at least one of the networks, to predict a future user experience quality level based on the predicted network quality level and/or past user experience quality levels, to determine an admission control policy based on the predicted future network quality level and the predicted future user quality level, to increase the future user experience quality level and to apply the determined admission control policy for the at least one traffic flow in the at least one network .

According to the invention it has first been recognized that an increased flexibility is provided, since by determining admission control policies based on predicted future network/service quality levels and predicted future user quality levels congestion is reduced, respectively avoided.

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According to the invention it has further been first recognized that by considering quality of service and quality of experience a reliable way to avoid or at least reduce congestion is provided.

5 According to the invention it has further been first recognized that a degradation in quality of service and/or quality of experience in the mobile network deployments is reduced.

10 Further features, advantages and preferred embodiments are described in the following subclaims.

15 According to a preferred embodiment the predicted quality levels are evaluated by determining a correlation value between actual and predicted values of the quality levels. One of the advantages is that this enables a reliable detection, whether and to what extent the predicted values and actual values correspond to each other: Strong correlations between the predicted values and the actual values indicate for example that there is a high probability at the moment to have a backhaul link experience traffic dynamics as predicted. If the satisfaction level, i.e. quality of experience, for a user is predicted to be low, admission control policies may be determined to increase the satisfaction level back to an acceptable level, i.e. a predetermined threshold, for example by decreasing a total number of user equipment connected to a femtocell network. Requests from new user equipment to handover from the first network e.g. a macrocell network to the second network e.g. a femtocell network or vice versa may be declined.

25 According to a further preferred embodiment the admission control policy includes splitting of data traffic between the two networks, preferably data traffic in form of IP flows. This enables the mobility of a flow or multiple flows of a user equipment from a first network with a congested backhaul link to a second network with a less congested backhaul link. This alleviates congestion in the backhaul link of the user equipment connected to the first network by moving remaining IP flow traffic to the second network. It is further possible to split the traffic of the same IP flow between the first and second network, i.e. have a certain percentage of the IP flow

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traffic serviced via the first network while the remaining portion of the IP flow traffic is moved to the second network.

5 According to a further preferred embodiment a user equipment determines actual user experience quality level and/or network/service quality level, preferably when handing off of a cell. When a user equipment determines actual user experience quality level and/or network/service quality level a more reliable determination is provided: The user may simply, for example, score, using a dedicated application installed on the user equipment, his experience.

10 According to a further preferred embodiment user experience quality data is collected when a user equipment hands off to a cell of the other network. When a user equipment hands off and the user experience quality data is collected at that moment a prompt and reliable statement directly from the user regarding his
15 quality of experience is achieved.

20 According to a further preferred embodiment a dedicated application, a web portal or a short message service is used for collecting user experience quality data from users. One of the advantages of a short message service for example is that a user is familiar with short message service SMS and therefore a user does not have to use new or unfamiliar services when he is required to provide user experience quality data. The advantage of a web portal is that this may be provided for a plurality of user equipment by a centralized server, for example located in the internet. Since more and more users use smartphones which
25 provide access to the internet a user may simply provide its experience quality data when accessing the internet.

30 According to a further preferred embodiment bandwidth usage between a mobile communication network, preferably a femto network, and a mobile traffic concentration point, preferably a mobile network operator's gateway is monitored for determining network/service quality. This enables an easy determination of network quality for example by and at the mobile traffic concentration point by one or more suitable traffic probing techniques.

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According to a further preferred embodiment a statistical profile of the network/service quality and/or the user experience quality, preferably periodically updated, is determined for predicting the future network/service quality level and/or the future user experience quality level. Statistical profiles provide, for example by weighing different past quality levels with each other, inter alia the advantage to inflict variations of network/service quality level and user experience quality level over time. For example a backhaul link bandwidth may vary during different periods of a day: The backhaul link may be accessed heavily during the day and accessed less at night. When the statistical profiles are periodically updated, preferably over a long period of time in the order of days or weeks, a reliable forecast or prediction of future network/service quality respectively user experience quality can be obtained.

According to a further preferred embodiment the statistical profile is split into different groups representing predefined parameters. This enables for example that the profile may be categorized into different groups for example application-specific, quality of service class identifier QCI-specific, closed subscriber group CSG-specific, diffserv codepoint-specific, user equipment-aggregate maximum bitrate-specific, user class-specific, for example VIP users versus ordinary users, users connecting to the first network for more than a certain time or users with history in providing reliable and trustworthy user experience quality data, etc..

According to a further preferred embodiment user equipment is triggered by an at least locally centralized network entity for providing user experience quality data. One of the advantages of a triggering via centralized network entity is, that the centralized network entity may not only know the network quality with regard to a specific user equipment but may also be aware of other network quality related information. Therefore a triggering by a centralized network entity which decides when to collect or provide user experience quality data provides enhanced respectively more reliable results.

According to a further preferred embodiment NAS-signalling is used for triggering the user equipment. NAS-signalling may be used to send directly a message to

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the user equipment, thus new communication channels for triggering are not needed. As a consequence very simple and reliable triggering is possible.

5 According to a further preferred embodiment user equipment is selected for providing user experience quality data based on one or more predefined network and/or user related parameters. Such parameters may be defined such that for example only users that have or received certain features like a particular service/application type, videos, etc. are selected for providing user experience quality data. Another example is that only users that have been connecting to the
10 first network for a time exceeding a specific threshold or only users that have been having active bearers with specific quality of service class identifiers QCI when they are connected to the first network, or only users that belong to a specific closed subscriber group CSG or only users with bearers with specific DiffServ Code Point or only users with an aggregate maximum bitrate satisfying a specific
15 condition or the like are selected.

According to a further preferred embodiment the user equipment triggers flow mobility and/or handover between the first and second mobile communication network based on the predicted future network/service quality level and/or
20 predicted future user experience quality level. This enables an automatic flow mobility and/or handover, so that a user of the user equipments is not bothered with unnecessary decisions.

25 According to a further preferred embodiment the flow mobility and/or the handover between the first and second mobile communication network is intervened by a user of the user equipment. This increases the flexibility since other network regulations may be met with user's consent.

30 According to a further preferred embodiment further resources to increase the predicted future network/service quality level and/or the predicted future user experience quality level are requested from an at least locally centralized network entity, preferably a policy and charging rule function, based on the predicted future network/service quality level and/or the predicted future user experience quality level. To request further resources for example the policy and charging rule

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function's interface to the broadband policy and charging rule BPCF function may be used. The interface between the policy charging rule function PCRF and the broadband policy control function BPCF may be used according to 3GPP TR 23.839. This enables for example a mobile network operator through to the policy and charging rule function to request for additional resource allocations from the fixed access network, which may be accepted or declined by the broadband policy control function BPCF following an admission control mechanism and if accepted they are enforced on the mobile traffic concentration point like a DSLAM or any other relevant node. One of the advantages is that this enables in a flexible way to further reduce congestion if congestion increases or is predicted to increase respectively the quality of service or quality of experience user level decreases or is predicted to decrease rapidly.

According to a further preferred embodiment of the system of claim 16 the quality mapper entity is located in a fixed network connecting one of the networks with a mobile operator network. One of the advantages is, that then the quality mapper entity may be used for different network deployments, for example different femtocell deployments on a same DSLAM.

According to a further preferred embodiment the quality mapper entity is collocated with the gateway of the fixed network. This enables a precise monitoring of for example bandwidth variations of the backhaul link between one of the networks and a mobile operator network at a corresponding gateway between the two networks using one or more suitable bandwidth probing techniques.

There are several ways how to design and further develop the teaching of the present invention in an advantageous way. To this end it is to be referred to the patent claims subordinate to patent claim 1 and patent claim 16 on the one hand and to the following explanation of preferred embodiments of the invention by way of example, illustrated by the figure on the other hand. In connection with the explanation of the preferred embodiments of the invention by the aid of the figure, generally preferred embodiments and further developments of the teaching will be explained. In the drawings

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Fig. 1 shows a system according to a first embodiment of the present invention;
Fig. 2 shows a schematically part of a method according to a second
embodiment; and

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Fig. 3 shows a method according to a third embodiment of the present invention.

Fig. 1 shows a system according to a first embodiment of the present invention.

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In Fig. 1 a femtocell network deployment is shown.

The shown system comprises a number of femtocells FC covering multiple
households/small offices in a wide residential area or forming an enterprise or
hotspot femtocell network, for example in a shopping mall or the like. The multiple
femtocells FC are according to Fig. 1 provided by the same mobile network
operator and connected through the same DSLAM or another node relevant to the
used fixed access technology to the mobile operator's core network ON via a
security gateway, an IP backbone, a DSLAM and a home (evolved) node B
gateway or the like. In Fig. 1 the case of a single mobile operator network ON
operating the femtocells FC and utilizing the fixed broadband network's DSLAM is
shown. However, the DSLAM can also be shared by femtocells FC operated by
different mobile network operators. In this case the DSLAMs are assumed to have
the capacity to individually identify the different mobile network operators using
one or more suitable methods or procedures. It is also assumed that each
individual mobile network operator has a so called service level agreement SLA
with the internet service provider ISP indicating maximum resources dedicated for
the mobile operator network at each DSLAM. Further it is assumed that for clock
and frequency synchronization and to avoid interferences the different femtocells
FC shown in Fig. 1 are assumed to be time-synchronized with the home (evolved)
node B gateway by using one or more suitable synchronization protocols.

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Further in Fig. 1 a mobile network operator's policy and charging rule function PCRF located in the operator's network ON and a broadband policy control function BPCF is shown. The policy and charging rule function PCRF and the broadband policy control function BPCF are in charge of defining an enforcing
5 interworking policy between mobile domains (radio access network) and fixed domains (IP backbone, operator/core network). These two functions PCRF and BPCF are connected to each other via an interface, defined by 3GPP TR 23.839 for fixed and/or mobile conversions. The mobile network operator may request to the policy and charging rule function PCRF for resource allocations from the IP
10 backbone network (fixed access network denoted with reference sign FN) which may be accepted or declined by the broadband policy control function BPCF following an admission control mechanism and if accepted they are enforced on the DSLAM or another relevant node. A user equipment UE which is connected or within reach of a femtocell FC of a home (evolved) node B may either use the femtocell FC for connecting via the home evolved node B, the DSL router, the DSLAM and further via the IP backbone and a security gateway or a home node B
15 gateway to the operator's network ON or use a macrocell MC via an (evolved) node B, which is part of the operator's network ON, forming the macrocell network MCN.

Further a so called quality of service/quality of experience mapper QoS/QoE mapper is collocated with the DSLAM according to Fig. 1. For example in case of an enterprise network or a shopping mall network, the QoS/QoE mapper can be collocated with the gateway of the enterprise network to the internet service
25 provider network. The QoS/QoE mapper may also be collocated with a home (evolved) node B gateway or any other appropriate entity. The quality of service/quality of experience QoS/QoE mapper may also be physically independent and implemented in a new node or entity or function at an existing node or entity.

30 The QoS/QoE mapper according to Fig. 1 monitors the bandwidth variation of the link between the femtocell network FCN and the security gateway/home node B gateway of the mobile network operator, using one or more suitable bandwidth probing techniques. The bandwidth of this link may vary during different periods of

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a day. For instance the link may be accessed heavily during the day and less accessed at night. To inflict these daily variations the QoS/QoE mapper develops a statistical profile over time of the bandwidth variation of the link over the IP backbone between the femtocell network FCN and the security gateway/home node B gateway. This statistical profile may constantly be updated over long periodic times, in the order of days or weeks. In the following this statistical profile is referred to as link bandwidth profile.

The QoS/QoE mapper keeps also track of another statistical profile, the so called QoS/QoE profile, whereby QoE is to be understood in terms of satisfaction level of users, which is averaged over a short and predetermined period of time Δ and mapped to quality of service QoS in terms of average link utilization and total number of users connected to the femtocell network FCN during this time period Δ . This quality of service/quality of experience QoS/QoE profile may be constantly updated through learning. As basis for the QoS/QoE profile an average user satisfaction level or mean opinion score MOS may be computed using any suitable function and based on one or more of the following inputs: A score ω_i indicated by a customer i , a duration θ_i during which a user was connected to the femtocell network FCN, types of applications/services received by the customer i , and/or average throughput λ_i achieved by the customer i while being connected to the femtocell network FCN.

In the initial stage, a corresponding database of the QoS/QoE profiles is empty. When the femtocell network FCN is in service, the QoS/QoE mapper uses customer satisfaction levels explicitly indicated by users to build the corresponding QoS/QoE profile. This QoS/QoE profile may be an online profile that learns a relation between user satisfaction and quality of service parameters in particular by using machine learning techniques, like neural networks, Bayesian inference, supervised learning, etc. This obtained QoS/QoE profile may then be categorized into multiple subprofiles that may be application-specific, quality of service class identifier QCI-specific, closed subscriber group CSG-specific, DiffServ Code Point-specific, user equipment-aggregate maximum bitrate-specific, user class-specific, for example VIP users, ordinary users, users connecting to the femtocell network

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FCN for more than a certain time, users with history in providing reliable and trustworthy scoring, etc..

5 The QoS/QoE mapper may collect feedback from users to determine user satisfaction upon performing handoff of a specific femtocell network FCN.

In Fig. 2 feedback collection by triggering a user equipment performing a handoff from a femtocell network to a macrocell network for a system of Fig. 1 is shown.

10 In a first step T1 a user equipment UE performs a handoff, for example from a femtocell network FCN to the macrocell network MCN. A mobility management entity MME may become aware of the handoff, which may be S1-based or X2-based. The mobility management entity MME then runs a policy logic to decide if the user equipment UE is to be contacted for scoring the service respectively to
15 collect a feedback from the users for user satisfaction in a second step T2. If yes, the mobility management entity MME may in a third step T3 trigger the QoS/QoE mapper or another corresponding node to send a short message service message to the user equipment UE to ask the user of the user equipment for opinion on the provided service i.e. the quality of the service. In a fourth step T4 the SMS
20 message is sent and feedback on the femtocell network service is then sent from the user equipment UE to the QoS/QoE mapper.

Further alternatively the mobility management entity MME may send directly a message to the user equipment using non-access-stratum signaling or a flag in a
25 handover command in the S1-based handover. In case an X2-based handover between the home evolve node B and an evolved node B is possible, the home evolved node B may be acquired with a specific policy following which it decides whether a user equipment needs to be contacted to provide feedback on service or not. The home evolved node B may then indicate a flag in an appropriate signal
30 message during the handover phase. When receiving this message or the flag the user equipment may be configured, for example to pop up a window, which may be used by the user to score the service and send feedback. This feedback may optionally include information on the user equipment UE, duration for which the user equipment UE was connected to the femtocell network FCN, the user

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equipment's average throughput while connected to the femtocell network FCN, etc., to the relevant node, in particular the QoS/QoE mapper.

5 It is further possible to use other quality of service related parameters for the quality of service/quality of experience mapper instead of link bandwidth, for example other metrics for a quality of service assessment like access delay, packet rate error at the IP backhaul or the like may be used.

10 The QoS/QoE mapper may provide in particular periodically admission control policies using a dedicated interface to the femtocells FC which may use preconfigured logic to interpret and enforce them. These policies may be determined by the QoS/QoE mapper based on the QoS/QoE levels predicted for future time periods. For example a handover of a user equipment UE to the femtocell network is admitted if acceptable user satisfaction level/quality of
15 experience is forecasted/foreseen. Otherwise the user will be requested to stay connected to the macrocell network MCN. As another example, from the quality of service/quality of experience predictions made by the QoS/QoE mapper, more resources may be seen to be required. Then the QoS/QoE mapper triggers the operator network ON, in particular the policy and charging rule function PCRF to
20 request the fixed operator network/IP backbone network for more resources using its interface to the broadband policy control function BPCF.

Fig. 3 shows a method according to a third embodiment of the present invention.

25 In Fig. 3 steps for an admission control mechanism are shown.

It is assumed that decisions on admission control policies to be sent to the femtocells are run periodically.

30 The periodicity of the admission control policy determination may be equal to a time Δ , the time over which for example the IP backhaul link bandwidth and the user satisfaction levels are averaged. At the beginning of each period $\Delta(k)$ the QoS/QoE mapper predicts the average link bandwidth P_k in a first step S1 from the relevant link bandwidth statistical profile based on past predictions P_{k-1} , P_{k-2} . The

accuracy of the link bandwidth prediction P_k may be assessed by comparing the predicted values P_{k-2} , P_{k-1} and the actual values M_{k-2} , M_{k-1} measured during a number of previous time periods $\Delta(k-2)$, $\Delta(k-1)$. The correlation CF1 between the predicted link bandwidth value P_k and the actual link bandwidth value M_k measured during a time period $\Delta(j)$ is denoted in Fig. 3 with $\Phi(j)$.

If a total number of users, connected through the femtocell network FCN is known and by using the predicted average link bandwidth P_k the quality of service/quality of experience mapper refers to the QoS/QoE profile or a particular profile such as QCI-specific to predict in a second step S2 the user satisfaction level SL_k during the upcoming time period $\Delta(k)$.

In a third step S3 this prediction is assessed by comparing the predicted user satisfaction values PSL_{k-2} , PSL_{k-1} and the actual satisfaction values SL_{k-2} , SL_{k-1} measured during a number of previous time periods $\Delta(k-2)$, $\Delta(k-1)$. This correlation $\psi(k-2)$, $\psi(k-1)$ is denoted with reference sign CF2 and represents the predicted user satisfaction value PSL_j and the actual user satisfaction value SL_j measured during a time period $\Delta(j)$. Strong correlations represented by a high value of the correlation CF2 between the predicted values PSL_{k-2} , PSL_{k-1} and the actual satisfaction values SL_{k-2} , SL_{k-1} as well as the corresponding bandwidth prediction and actual values P_{k-2} , P_{k-1} , M_{k-2} , M_{k-1} indicate that in the current time interval $\Delta(k)$ there is a high probability to have the IP backhaul link experience traffic dynamics as predicted from the corresponding link bandwidth statistical profile obtained in step S1 and similar to the value P_k and also to experience a user satisfaction level similar to the value PSL_k predicted from the QoS/QoE statistical profile according to step S2.

If the satisfaction level SL is predicted to be low, the QoS/QoE mapper defines in a first step S4 an admission control policy that shall enforce measures at femtocells FC to increase the satisfaction level SL to a predefined acceptable value, for example by decreasing a total number of users connected to the femtocell network FCN to a certain value according to the QoS/QoE statistical profile. This may be provided in form of an admission control policy which enables/enforces IP flow mobility between the macrocell network MCN and the femtocell network FCN with

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the user equipment having a cellular radio capability, and/or by declining requests for new users/user equipment to handoff from the macrocell network MCN to the femtocell network FCN or the like.

- 5 A user currently connected with its user equipment UE to the femtocell network FCN may be requested to move a set of his IP flows to the macrocell network MCN. A user may also be requested alternatively or additionally to split the traffic of the same IP flow between the macrocell network MCN and the femtocell network FCN. This means that a certain percentage of IP flow data traffic is serviced via the femtocell network FCN while the remaining portion of the IP flow data traffic is moved to the macrocell network MCN.
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- In the following the situation is described that a user experiences a degradation in quality of service after being admitted to the femtocell network: Such a degradation of the quality of service may be for example visually perceived by the user or automatically detected by his user equipment using one or more suitable quality of experience models and/or considering one or more quality of service metrics such as delay, delay variation, jitter, packet loss, etc.. It is assumed that the quality of experience assessment is assumed to be conducted by the user equipment by using different quality of experience models. This is in contrast to the QoS/QoE mapper which assesses the quality of experience based on the feedback received from users, duration of connection through the femtocell network FCN, average throughput of users, etc..
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- 25 If the quality of service degradation lasts for a time longer than a predetermined period of time and/or reaches a certain level, for example specific values of the considered quality of service metrics, a user may manually trigger a handoff request and/or a flow mobility from the femtocell network FCN to the macrocell network MCN. Alternatively, the user equipment may be triggered to do so automatically, i.e. without user intervention.
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It is also possible that this may be applied to entirely or partially move a specific flow from a 3GPP wireless domain, for example a femtocell network or macrocell network to another network, for example public Wi-Fi hotspot network or the like.

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In this regard when a user intends to perform a bandwidth intensive application like download of a youtube video, the user may be instructed via a pop up message to turn on his/her Wi-Fi radio to perform this task. The user equipment may be preconfigured to automatically perform this operation based on quality of experience assessment by the user equipment. This operation may be performed even during service time if the quality of service degrades during the service to an unacceptable level.

In summary the present invention provides a method and a system that predicts and assesses a variation of quality of service metrics in the future such as network load or congestion indications. The present invention further predicts and assesses an impact of quality of service variation on users' quality of experience, for example represented by a metric indicating an average user satisfaction level and based on these two predictions defines policies for admitting a user equipment and/or a traffic flow of the user equipment wishing to handover from a first network to a second network, for example a macrocell network to a femtocell network or vice versa.

Further IP flow mobility including multi homing may be enforced between those two networks as a proactive measure to encounter any possible degradation in quality of service/quality of experience. Information on user satisfaction may be collected explicitly from users when they handout/-off for example from the femtocell network. Users may be requested to score the satisfaction level and they can be selected randomly or by a defined logic, for example only users that received a particular service/application type, video, or only users that have been connected to the femtocell network for a time exceeding a specific threshold or users that have been having active bearers with a specific quality of service class identifiers QCI when connected to the femtocell network, or only users that belong to a specific close subscriber group CSG, or only users with bearers with a specific DiffServ Code Point, or users with an aggregate maximum bitrate satisfying a specific condition or the like. Namely it may be selected out of a group of users that have handed out from the femtocell network. For example these users may be given incentives for scoring the service. Such a user satisfaction level can be for

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example a score from one to five with five indicating an excellent perceived quality and one indicating a poor service.

5 Satisfaction levels may be collected for instance using short message service SMS through a web portal or a dedicated application. For many mobile network operators, using femtocell for data offload or other purposes is still a new service or “yet to be launched” service. Mobile network operators may then want to evaluate the satisfaction of their customers at an initial phase of the service to access and ensure adequate deployment of resources. The quality of
10 service/quality of experience mapper may collect feedback from users upon performing a handoff out of the specific femtocell network. For example it could be that the mobility management entity is acquired with a specific policy following which it decides whether a user needs to be contacted to provide feedback on service or not. An example of these policies can be, that “a user equipment having
15 an active bearer with specific QCI needs to be contacted for feedback on service after handover from femtocell network to macrocell network” or “user equipment belonging to specific closed subscriber group CSG needs to be contacted for feedback on femtocell network service after handover from femtocell network to macrocell network”. These policies may be provided by the quality of
20 service/quality of experience mapper or by any other corresponding mobile network node, for example the policy and charging rule function PCRF.

The following abbreviations are used in particular with the Fig. 1-3:

25	UE	User Equipment
	IP	Internet Protocol
	QoS	Quality of Service
	QoE	Quality of Experience
	HNB GW	Home NodeB Gateway
30	HeNB	Home evolved NodeB
	DSL	Digital Subscriber Line
	DSLAM	Digital Subscriber Line Access Multiplexer
	PCRF	Policy and Charging Rules Function
	BPCF	Broadband Policy Control Function

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SMS Short Message Service
SLA Service Level Agreement
MOS Mean Opinion Square

5 The present invention provides inter alia an integration both of quality of service
and quality of experience in the admission control of handovers between networks,
in particular between macrocell networks and femtocell networks. The present
invention further enables users or user equipment to trigger flow mobility or
vertical/horizontal handover based on quality of service measurements/quality of
10 experience assessment. The present invention provides the advantage of explicit
scoring of femto communication services by users. A further advantage is that
quality of service/quality of experience based admission control of flow
mobility/handovers from macrocell networks to femtocell networks is provided. An
even further advantage is that quality of service/quality of experience based flow
15 mobility or vertical/horizontal handover triggering is provided.

Many modifications and other embodiments of the invention set forth herein will
come to mind the one skilled in the art to which the invention pertains having the
benefit of the teachings presented in the foregoing description and the associated
20 drawings. Therefore, it is to be understood that the invention is not to be limited to
the specific embodiments disclosed and that modifications and other embodiments
are intended to be included within the scope of the appended claims. Although
specific terms are employed herein, they are used in a generic and descriptive
sense only and not for purposes of limitation.

25

Claims

1. A method for admission control of at least one traffic flow of a user equipment (UE) from one cell (MC) of a first mobile communication network (MCN) to another cell (FC) of a second mobile communication network (FCN), preferably from a cell (MC) of a macrocell network (MCN) to a cell (FC) of a femtocell network (FCN),
5 characterized by the steps of
- 10 e) Predicting (S1) a future network/service quality level (P_k) based on past network/service quality levels (M_{k-1} , M_{k-2}) of at least one (FCN) of the networks,
- f) Predicting (S2, S3) a future user experience quality level (PSL_k) based on the predicted network quality level (P_k) and/or past user experience quality levels (SL_{k-2} , SL_{k-1}),
15 g) Determining (S4) an admission control policy based on the predicted future network/service quality level (P_k) and the predicted future user experience quality level (PSL_k), to increase the future user experience quality level (SL_k),
- 20 h) Applying the determined admission control policy for the at least one traffic flow in at least one network (FCN).
2. The method according to claim 1, characterized in that the predicted quality levels (P_k , SL_k) are evaluated by determining a correlation value (CF1, CF2)
25 between actual (M_{k-2} , M_{k-1} , SL_{k-2} , SL_{k-1}) and predicted values (P_{k-2} , P_{k-1} , PSL_{k-2} , PSL_{k-1}) of the quality levels.
3. The method according to one of the claims 1-2, characterized in that the admission control policy includes splitting of data traffic between the two networks (FCN, MCN), preferably data traffic in form of IP flows.
30
4. The method according to one of the claims 1-3, characterized in that a user equipment (UE) determines actual user experience quality level (SL_k) and/or network/service quality level (M_k), preferably when handing off of a cell (FC).

- 20 -

5. The method according to one of the claims 1-4, characterized in that user experience quality data is collected when a user equipment (UE) handoffs to a cell of the other network (ON).

5

6. The method according to claim 5, characterized in that for collecting user experience quality data from users a dedicated application, a web portal or a short message service is used.

10

7. The method according to one of the claims 1-6, characterized in that for determining network/service quality bandwidth usage between a mobile communication network preferably the femtocell network (FCN) and a mobile traffic concentration point (DSLAM), preferably a mobile network operator's gateway, is monitored.

15

8. The method according to one of the claims 1-7, characterized in that for predicting the future network/service quality level (P_k) and/or the future user experience quality level (PSL_k) a statistical profile of the network/service quality and/or the user experience quality, preferably periodically updated, is determined.

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9. The method according to claim 8, characterized in that the statistical profile is split into different groups representing predefined parameters.

10. The method according to one of the claims 1-9, characterized in that user equipment (UE) is triggered by an at least locally (locally) centralized network entity (QoS/QoE mapper) for providing user experience quality data.

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11. The method according to claim 10, characterized in that NAS-signalling is used for triggering the user equipment (UE).

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12. The method according to one of the claims 10-11, characterized in that user equipment (UE) is selected for providing user experience quality data based on one or more predefined network and/or user related parameters.

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13. The method according to one of the claims 1-12, characterized in that the user equipment (UE) triggers flow mobility and/or handover between the first and second mobile communication network (FCN, MCN) based on the predicted future network/service quality level and/or predicted future user experience quality level

5

14. The method according to claim 13, characterized in that the flow mobility and/or the handover between the first and second mobile communication network (FCN, MCN) is intervened by a user of the user equipment (UE)

10

15. The method according to one of the claims 1-14, characterized in that based on the predicted future network/service quality level and/or the predicted future user experience quality level further resources to increase the predicted future network/service quality level and/or the predicted future user experience quality level are requested from an at least locally centralized network entity, preferably a Policy and Charging Rule Function (PCRF).

15

16. A system for admission control of at least one traffic flow of a user equipment (UE) from one cell (MC) of a first mobile communication network (MCN) to another cell (FC) of a second mobile communication network (FCN), preferably from a cell (MC) of a macrocell network (MCN) to a cell (FC) of a femtocell network (FCN), preferably for performing with a method according to one of the claims 1-15, characterized by

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a quality mapper entity (QoS/QoE mapper) configured to be operable to predict (S1) a future network/service quality level (P_k) based on past network quality/service levels (M_{k-1} , M_{k-2}) of at least one (FCN) of the networks, to predict (S2, S3) a future user experience quality level (PSL_k) based on the predicted network quality level (P_k) and/or past user experience quality levels (SL_{k-2} , SL_{k-1}), to determine (S4) an admission control policy based on the predicted future network quality level (P_k) and the predicted future user quality level (PSL_k), to increase the future user experience quality level (SL_k) and to apply the determined admission control policy for the at least one traffic flow in the at least one network (FCN).

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17. The system according to claim 16, characterized in that the quality mapper entity (QoS/QoE mapper) is located in a fixed network (FN) connecting one of the networks (FCN) with a mobile operator network (ON) .

5 18. The system according to claim 17, characterized in that the quality mapper entity (QoS/QoE mapper) is collocated with a gateway (DSLAM) of the core network (FN).

10 19. The system according to one of the claims 15-18, characterized in that the user equipment is configured to be operable to trigger flow mobility and/or handover between the first and second mobile communication network (FCN, MCN) based on the predicted future network/service quality level and/or predicted future user experience quality level.

15 20. The system according to claim 19, characterized in that the user equipment is configured to be operable to recognize user intervention with regard to the triggering.

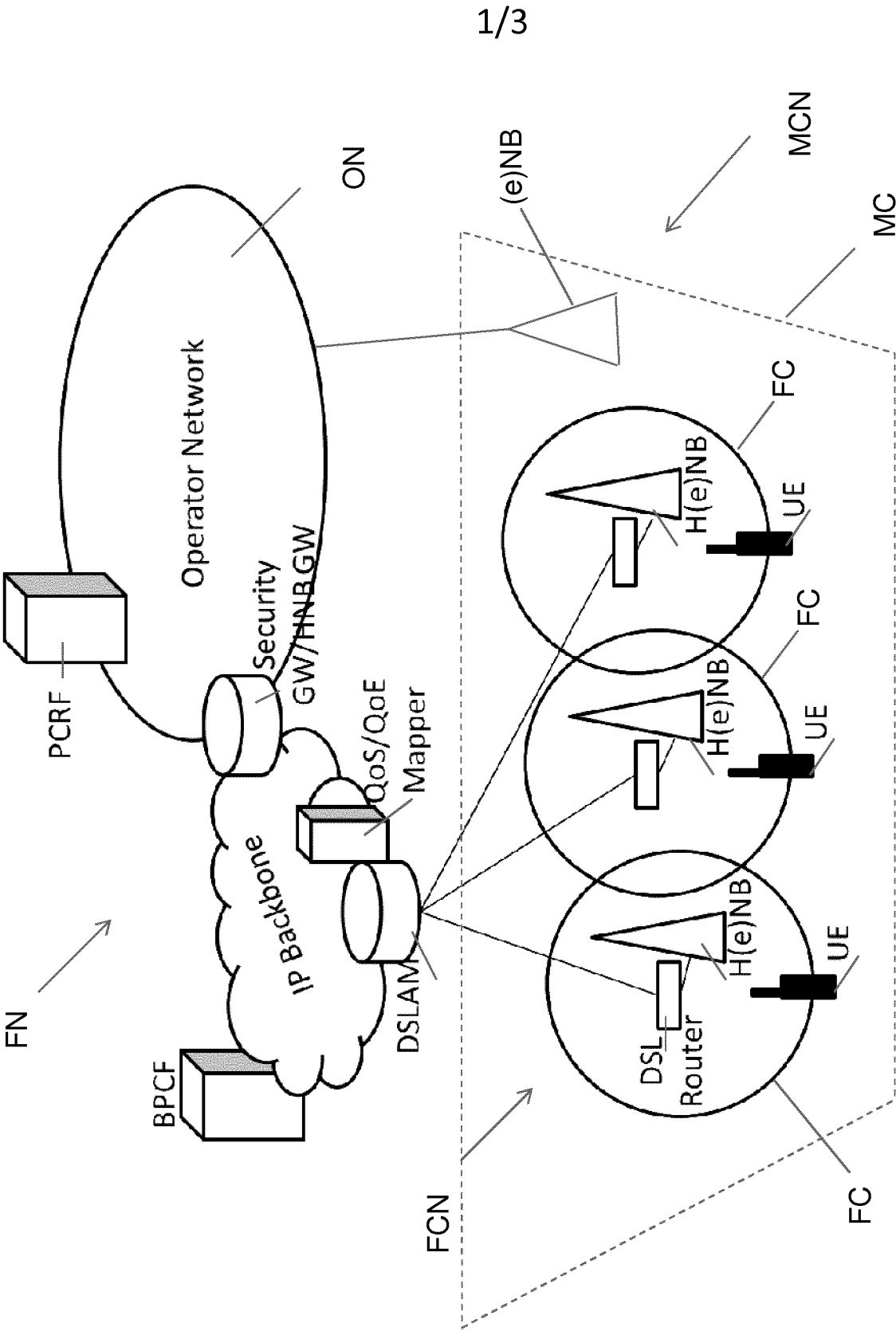


Figure 1

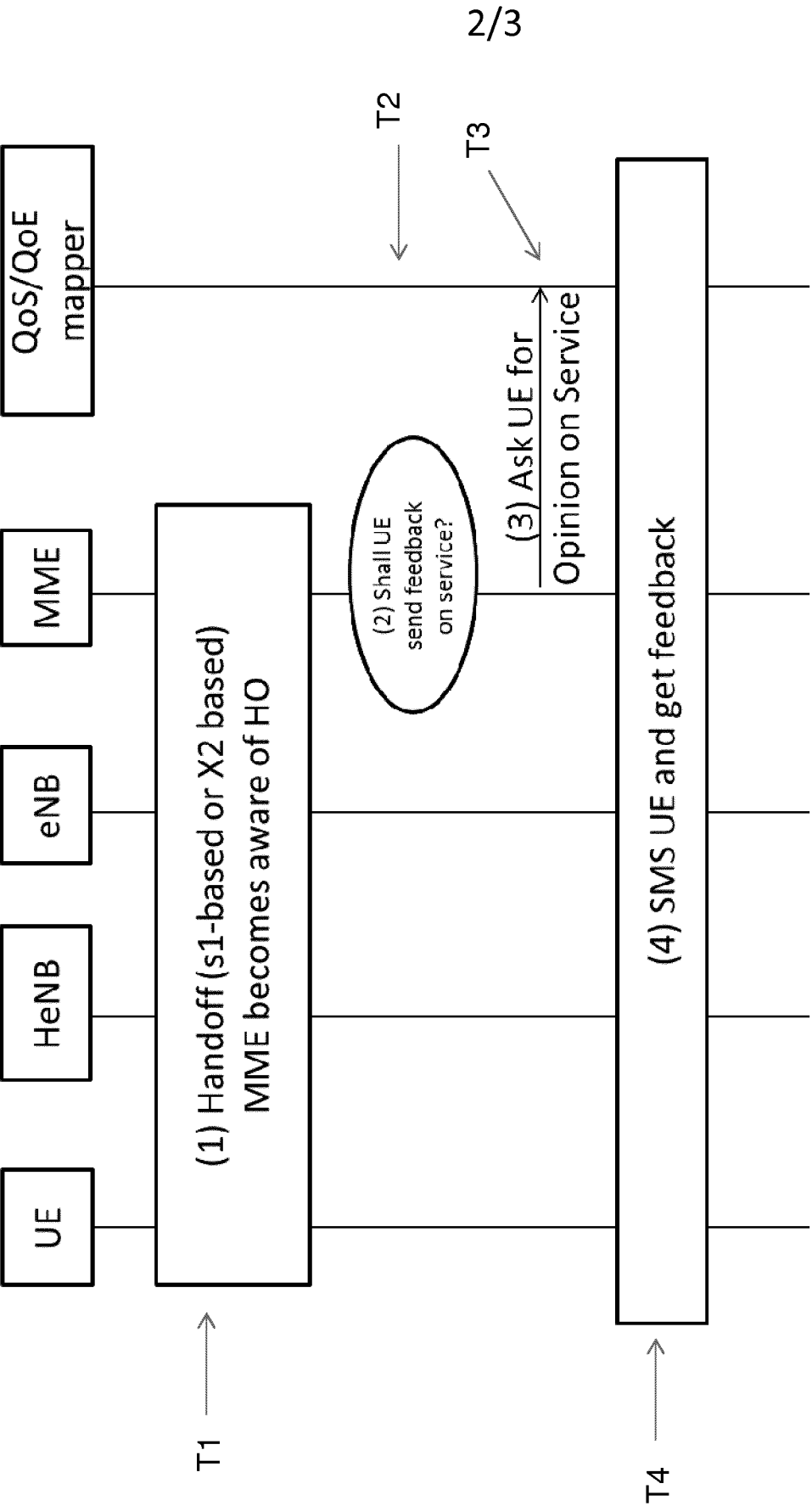


Figure 2

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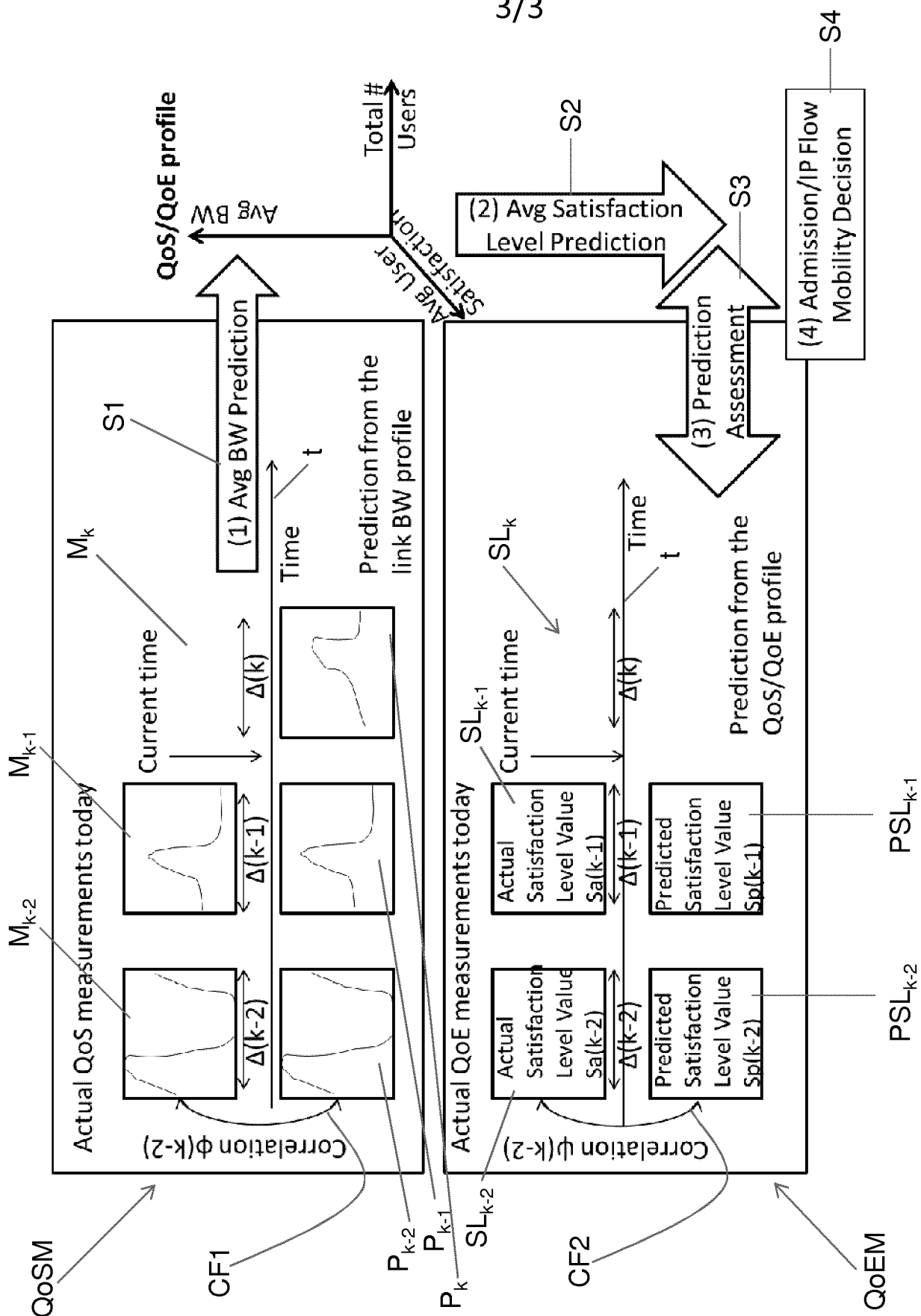


Figure 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2012/068468

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W28/00

ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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.
Y	US 2006/099933 A1 (BENVENISTE MATHILDE [US]) 11 May 2006 (2006-05-11) paragraphs [0049], [0061], [0137], [0088], [0042] -----	1-20
Y	GB 2 461 516 A (TOSHIBA RES EUROP LTD [GB]) 6 January 2010 (2010-01-06) page 3, line 10 - line 25 page 5, line 15 - line 30 -----	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

"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

13 February 2013

Date of mailing of the international search report

21/02/2013

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/068468

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006099933	A1	11-05-2006	NONE

GB 2461516	A	06-01-2010	NONE
