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(54) Title: SIGNALLING METHOD AND APPARATUSES SUPPORTING QoE-AWARE RADIO RESOURCE ALLOCATION

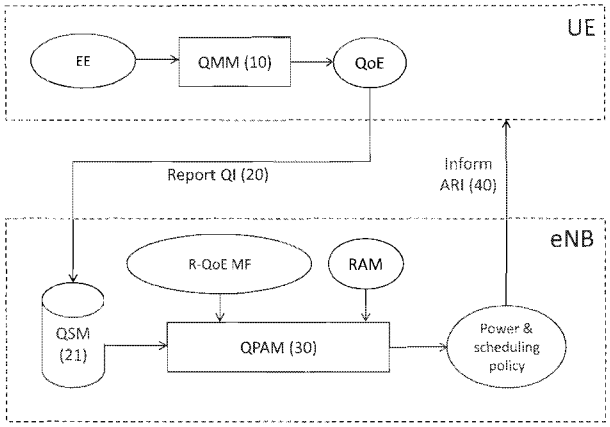


Figure 1

(57) Abstract: The invention concerns a signalling method supporting QoE-aware radio resource allocation in a radio network comprising an access point (eNB) and at least one user equipment (UE) capable of establishing a connection with the access point (eNB), the method comprising the following steps: in a QoE Measurement Module (QMM) of the user equipment (UE), measuring (10) a QoE information data; reporting (20) the measured QoE information data to the access point (eNB), in a QoE-aware Resource Allocation Module (QRAM) of the access point (eNB), determining (30) resources to be allocated to each user equipment connected to the access point as a function of a preconfigured allocation mode (RAM)and of the measured QoE information data reported by each user equipment, informing (40) each user equipment (UE) with the resources said user equipment is allocated.

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Signalling method and apparatuses supporting QoE-aware radio resource allocation

TECHNICAL FIELD

The invention relates to radio network, and more specifically to user-centric radio resources allocation techniques in a radio network.

BACKGROUND

Different types of metrics are known to evaluate the performance of wireless communication systems.

"Quality of Service" (QoS) evaluation methods are based on objective metrics referring to network requirements. Examples of QoS metrics are the bitrate or the jitter.

On the opposite, "Quality of Experience" (QoE) evaluation methods are based on the end user perception of the performance of the network.

Many research works have been done on the user-centric radio resource allocation algorithms.

The article "Multiuser Resource Allocation: Maximizing the Perceived Quality" written by A. Saul and G. Auer and published in the EURASIP Journal in January 2009 proposes an optimum multiuser resource allocation strategy with the objective to maximize the user-perceived quality of the data transmission by cross-layer optimization of the application layer and the MAC (*Medium Access Control*) layer.

In the article "Q-DRAM QoE-based Dynamic Rate Adaptation Mechanism for Multicast in Wireless Networks" written by K. Piamrat et al. and published in IEEE GLOBECOM in december 2009, a mechanism is proposed to dynamically adapt the transmission rate of multicast packets sent to users to a higher or lower level based on the feedback of user's QoE in WLAN.

Signalling methods supporting the QoE-aware radio resource allocation and related apparatuses are not widely reported.

The software program in US20080155087 allows the end user QoE to be qualified and translated into network conditions, i.e. QoS, which are required for that QoE. Accordingly, the system can be designed or operated to gain high QoE with the support of an additional QoE server.

However, the cost of an additional QoE server in US20080155087 is fairly large and the mapping from QoE to QoS may be difficult to implement since it is difficult to extract multiple QoS parameters from a single QoE parameter.

A disadvantage of this method is that the resource allocation technique is centralized.

SUMMARY

The invention aims to facilitate the user-centric radio resource allocation techniques. In this respect, the invention provides a signalling method supporting Quality of Experience, or QoE,-aware radio resource allocation in a radio network comprising an access point and at least one user equipment capable of establishing a connection with the access point, the method comprising the following steps, executed by the access point:

- Receiving a QoE information data measured in a QoE Measurement Module of the user equipment;
- In a QoE-aware Resource Allocation Module of the access point, determining resources to be allocated to each user equipment connected to the access point as a function of a allocation mode and of the received QoE information data,
- Informing each user equipment with the resources said user equipment is allocated.

The invention thereby provides the signalling and functional modules which are required to support QoE-aware resource allocation in a radio network. One advantage of the invention is that the radio network does not require a QoE-aware server processing QoE information data from all user equipments connected to the entire network. The QoE-aware resource allocation is indeed performed at the access point level in the radio network, each access point being connected to a limited number of user equipments. This allows a specific resource allocation policy to be performed in each access point.

Other preferred but non limitative aspects of the invention are as follows:

- the signalling method further comprises storing the received QoE information data into a storage memory of the access point;
- resources determination comprises determining a scheduling policy and a power level to be allocated to each user equipment;
- to determine the resources to be allocated to each user equipment the signaling method comprises the following sub-steps:
    - For each user equipment, determining a predicted QoE information data as a function of the QoE information data received from said user equipment and of a resource-QoE mapping function,
    - Determining a scheduling policy and a power level to be allocated to each user equipment as a function of the predicted QoE information data of all user equipments and of the allocation mode;

- the QoE information data is transmitted to the access point through a dedicated field of a message transmitted through an uplink control channel established between the user equipment and the access point;
- the resources allocated to a given user equipment are transmitted to the user equipment through a dedicated field of a message transmitted through a downlink control channel established between the user equipment and the access point;
- the signalling method further comprises a step of determining the power allocation mode.

The invention also relates to a method for supporting Quality of Experience, or QoE,-aware radio resource allocation in a radio network comprising an access point and at least one user equipment capable of establishing a connection with the access point, the method comprising the following steps, executed by the user equipment :

- in a QoE Measurement Module of the user equipment, measuring a QoE information data;
- transmitting the measured QoE information data to the access point,
- receiving a message comprising information related to the resources allocated to the user equipment, said allocated resources being determined by a QoE-aware Resource Allocation Module of the access point as a function of an allocation mode and of the measured QoE information data.

The invention further relates to an access point of a radio network supporting Quality of Experience, or QoE,-aware radio resource allocation, said access node being capable of establishing a connection with at least one user equipment, said access node comprising:

- means for receiving a QoE information data measured in a QoE Measurement Module of the user equipment;
- means for determining resources to be allocated to each user equipment connected to the access point as a function of an allocation mode and of the received QoE information data, said means being called QoE-aware Resource Allocation Module,
- means for informing each user equipment with the resources said user equipment is allocated.

The invention further covers a communication network comprising at least one access point as defined above, each access point being capable of being connected to at least one user equipment.

And the invention further relates to a computer program product comprising code instructions that perform the process comprising the following steps, when executed by a processor of an access point as defined above :

- receiving measured QoE information data from user equipments connected to the access point,
- determining resources to be allocated to each user equipment connected to the access point as a function of a allocation mode (RAM) and of the measured QoE information data reported by each user equipment,
- Informing each user equipment with the resources said user equipment is allocated.

DRAWINGS

Figure 1 shows a QoE-aware signalling method between one access point (eNB) and one user equipment (UE) according to an embodiment of the invention.

Figure 2 shows an embodiment of the QoE-aware resource allocation steps included in the QoE-aware signalling method of the invention.

DETAILED DESCRIPTION OF THE INVENTION

With reference to **figure 1**, the invention involves two types of network devices: access points eNB and user equipments UE.

The user equipment UE is a terminal such as a cellular phone, comprising a QoE Measurement Module QMM. This QoE Measurement Module QMM is configured to quantify the perceptual opinion of the end-user, i.e. the user of the user equipment, in terms of QoE (*Quality of Experience*). Such a QoE Measurement Module QMM computes QoE information data retrieved from input effecting elements EE characterizing the user perception of a service. For example, in the case of video streaming context, possible effecting elements EE are the delay spent in zapping between channels or the quality of the image displayed on the screen of the user equipment.

The user equipment UE is capable of establishing a wireless connection with a remote access point eNB included in the radio network. This connection comprises a least two control channels: a downlink control channel carrying data from the access point eNB to the user equipment UE and an uplink control channel carrying data from the user equipment UE to the access point eNB.

The access point eNB is a device that can be connected to one or many user equipments in its close vicinity. It can be for instance a "E-UTRAN NodeB" device which is commonly used in terrestrial radio networks.

Only one user equipment UE is depicted on figure 1 but this must not be considered as a limitation. The invention is of course designed to work with many user equipments.

In the following, let N be the number of user equipments UE that are connected to the access point eNB.

The access point can simultaneously transmit data corresponding to different types of services (for instance video or audio) to the N user equipments.

Data transmission requires the access point eNB to allocate resources to the N user equipments. The access point has to split a limited amount of resources into N partitions, one for each user equipment. For this purpose, the access point eNB comprises a QoE-aware Resource Allocation Module QRAM which can determine the resource allocation based on a Resource Allocation Mode RAM and a corresponding QoE-aware resource allocation algorithm.

More particularly, in the present description, resource allocation refers to scheduling and power allocation. By scheduling we refer the problem of determining which user equipments will be active in a given time-slot; by power allocation we refer to the problem of allocating power (a physical layer resource) among these active user equipments.

- Power allocation, broadly speaking, is the intelligent selection of transmit power in a communication system to achieve good performance within the system. In general, for any particular set of channel conditions, a higher transmit power translates into a higher signal power at the receiver. Having a higher signal-to-noise ratio (SNR) at the receiver reduces the bit error rate of a digital communication link.
- Scheduling refers to methods by which threads, processes or data flows are given access to system resources (e.g. processor time, communications bandwidth). In advanced packet radio wireless networks such as HSDPA (High-Speed Downlink Packet Access) 3.5G cellular system, channel-dependent scheduling may be used to take advantage of channel state information. If the channel conditions are favorable, the throughput and system spectral efficiency may be increased.

In an embodiment of the invention, the QoE-aware Resource Allocation module QRAM comprises two sub-modules, a QoE Prediction Module QPM and a QoE-aware Scheduling and Power Allocation Module QSPAM. The former one predicts the potential QoE of user equipments and the latter performs scheduling and power allocation according to the reported and predicted user equipment QoE.

The access point eNB preferably comprises a QoE Storage Memory QSM capable of storing QoE information data and reading out this information when necessary.

An embodiment of the signalling method of the invention will now be described in detail.

In the first step of this method, referred to as step 10 in figure 1, the QoE Measurement Module QMM of a user equipment UE measures a QoE information data from predefined effecting elements.

This QoE information data may for instance be a score value. The higher this value is, the better quality was perceived by the end user of the user equipment.

This QoE information data is preferably an average value over a predetermined period.

The measured QoE information data is then reported (step 20 on figure 1) to the access point eNB the user equipment is connected to. This data may be carried in a dedicated field of a message transmitted through the uplink control channel, for instance referred to as the QoE Indicator (QI) field.

In step 21, the user equipment QoE is then updated in the QoE Storage Memory QSM of the access point which is used to store the user equipment QoEs in the access node (eNB).

Of course, measurement (10), reporting (20) and storage (21) steps are performed for N connected user equipments independently from each other. Once all user equipments have reported at least one QoE information data, N QoEs scores become available for reading in the QoE Storage Memory QSM at any time.

The QoE-aware Resource Allocation Module QRAM in the access point eNB then performs resource allocation so as to improve the system performance in terms of QoE. For this purpose, the QoE-aware Resource Allocation Module QRAM performs at step 30 resource allocation according to a Resource Allocation Mode RAM which defines the QoE-aware resource allocation algorithm and taking into account the reported QoE information data, which can be read out from the QoE Storage Memory QSM.

In a particular embodiment depicted on figure 2, the QoE-aware Resource Allocation Module QRAM comprises two sub-modules each performing a sub-step of the resource allocation step 30.

For each of the N user equipments, a QoE Prediction Module QPM of the QoE-aware Resource Allocation Module QRAM determines at first sub-step 31 a predicted QoE information data $PQoE_1$, $PQoE_2$, ..., $PQoE_N$ as a function of the QoE information data QoE_1, QoE_2, ..., QoE_N reported by the corresponding user equipment and of a resource-QoE mapping function "R-QoE MF".

The resource-QoE mapping function "R-QoE MF" is employed to quantify the relationship between resource and QoE so that the QoE-aware Resource Allocation Module QRAM can calculate the allocated resource based on this function. This function may

consist of a number of elements, for example, the channel state, depending on the specified definition of QoE.

In the second sub-step 32, the QoE-aware Scheduling and Power Allocation Module QSPAM determines a scheduling policy and a power level to be allocated for each of the N user equipments as a function of the predicted QoE information data $PQoE_1$, $PQoE_2$, ..., $PQoE_N$ of the N user equipments and of the Resource Allocation Mode RAM. It should be noted that reported QoE information data can be directly used as input of the QoE-aware Scheduling and Power Allocation Module QSPAM in place of the predicted QoE information data computed by the QoE Prediction Module QPM, in particular depending on the preconfigured Resource Allocation Mode RAM.

At the step 40, the N user equipments are informed about the new resource allocation that has just been applied by the access point eNB. This information is preferably carried in a dedicated field of a message transmitted through the downlink control channel, for instance referred to as the Allocated Resource Indicator (ARI) field. The nature of this information can be of any type: a simple notification message or a more complex message containing for instance a parameter representing a signal quality.

The method described above can be repeated as long as user equipments UE are connected to the access point eNB.

Multiple resource allocation modes RAM can be used, such as the "basic mode" which consists in allocating an equal power to the N user equipments connected to the access point eNB and using the well-known Round Robin scheduling policy.

In addition to the basic mode, other advanced resource allocation modes RAM may be configured in the access point eNB. Some of them are listed as follows:

- Maximization mode: in order to gain the maximum total QoE score of all user equipments, allocate more resources to user equipments who can achieve a higher QoE score and less to those who bears a lower QoE score. The power allocated to a user equipment may for instance be proportional to its QoE score.
- Fairness mode: Considering the fairness issue, allocate more power to user equipments with a lower average QoE score and less to those with a higher average QoE score. The average QoE is preferably the QoE measured by user equipment in a predetermined period.
- Greedy mode: Allocate more resources to user equipments who can achieve higher ratio of increment QoE to average QoE and less to those with lower ratio. The increment QoE is defined as the increment of QoE if a certain amount of resources is added to a certain basic level which should be lower than the average resource level.

- Priority mode: Allocate resources in accordance with user equipment priorities. In detail, allocate more resources to user equipments with high priorities and less to those with low priorities. The priority may be determined by the type of services or the type of user equipments.
- Requirement mode: Allocate resources to the first user equipment so that this user can fulfil its requirement of QoE, and allocate resources to the second user equipment and so on in the same manner. The order of user equipments may be dependent on priorities or other rules.

The access point eNB may be preconfigured once with a static resource allocation mode RAM.

Nonetheless, the access point eNB is preferably capable of dynamically choosing the most appropriate resource allocation mode depending on criteria such as the number of connected user equipments and/or the service type.

The invention further relates to a radio network comprising at least one access point eNB, the at least one access point eNB being connected to at least one user equipment UE and configurable with identical or distinct resource allocation modes (RAM).

The invention also relates to a computer program product comprising code instructions that performs steps of method described above when executed by an processor of an access point eNB as described above.

CLAIMS

1. A signalling method supporting Quality of Experience, or QoE,-aware radio resource allocation in a radio network comprising an access point (eNB) and at least one user equipment (UE) capable of establishing a connection with the access point (eNB), the method comprising the following steps, executed by the access point:

- Receiving (20) a QoE information data measured (10) in a QoE Measurement Module (QMM) of the user equipment (UE);
- In a QoE-aware Resource Allocation Module (QRAM) of the access point (eNB), determining (30) resources to be allocated to each user equipment connected to the access point as a function of a allocation mode (RAM) and of the received QoE information data,
- Informing (40) each user equipment (UE) with the resources said user equipment is allocated.

2. The method according to claim 1, further comprising storing (21) the received QoE information data into a storage memory (QSM) of the access point (eNB).

3. The method according to any one of claims 1-2, wherein resources determination comprises determining (32) a scheduling policy and a power level to be allocated to each user equipment (UE).

4. The method according to any one of claims 1-3, wherein to determine the resources to be allocated to each user equipment it comprises the following sub-steps:

- For each user equipment, determining (31) a predicted QoE information data as a function of the QoE information data received from said user equipment (UE) and of a resource-QoE mapping function,
- Determining (32) a scheduling policy and a power level to be allocated to each user equipment (UE) as a function of the predicted QoE information data of all user equipments and of the allocation mode (RAM).

5. The method according to any one of claims 1-4, wherein the measured QoE information data is a QoE information data averaged over a predetermined period.

6. The method according to any one of claims 1-5, wherein the QoE information data is transmitted to the access point (eNB) through a dedicated field (QI) of a message

transmitted through an uplink control channel established between the user equipment and the access point.

7. The method according to any one of claims 1-6, wherein the resources allocated to a given user equipment are transmitted to the user equipment through a dedicated field (ARI) of a message transmitted through a downlink control channel established between the user equipment and the access point.

8. The method according to any one of claims 1-7, wherein the power allocation mode (RAM) is a basic mode consisting in allocating an equal power to each user equipment (UE) using a Round-Robin scheduling policy.

9. The method according to any one of claims 1-8, further comprising a step of determining the power allocation mode (RAM).

10. A method for supporting Quality of Experience, or QoE,-aware radio resource allocation in a radio network comprising an access point (eNB) and at least one user equipment (UE) capable of establishing a connection with the access point (eNB), the method comprising the following steps, executed by the user equipment :

- in a QoE Measurement Module (QMM) of the user equipment (UE), measuring (10) a QoE information data;
- transmitting (20) the measured QoE information data to the access point (eNB),
- receiving (40) a message comprising information related to the resources allocated to the user equipment, said allocated resources being determined by a QoE-aware Resource Allocation Module (QRAM) of the access point (eNB) as a function of an allocation mode (RAM) and of the measured QoE information data.

11. An access point (eNB) of a radio network supporting Quality of Experience, or QoE,-aware radio resource allocation, said access node (eNB) being capable of establishing a connection with at least one user equipment (UE), said access node (eNB) comprising:

- means for receiving (20) a QoE information data measured (10) in a QoE Measurement Module (QMM) of the user equipment (UE);
- means for determining (30) resources to be allocated to each user equipment connected to the access point as a function of an allocation mode (RAM) and of the received QoE information data, said means being called QoE-aware Resource Allocation Module (QRAM),

- means for informing (40) each user equipment (UE) with the resources said user equipment is allocated.

12. A communication network comprising at least one access point according to claim 11, each access point being capable of being connected to at least one user equipment.

13. A computer program product comprising code instructions that perform the process comprising the following steps, when executed by a processor of an access point (eNB) according to claim 11 :

- receiving (20) measured QoE information data from user equipments connected to the access point (eNB),
- determining (30) resources to be allocated to each user equipment connected to the access point as a function of a allocation mode (RAM) and of the measured QoE information data reported by each user equipment,
- Informing (40) each user equipment (UE) with the resources said user equipment is allocated.

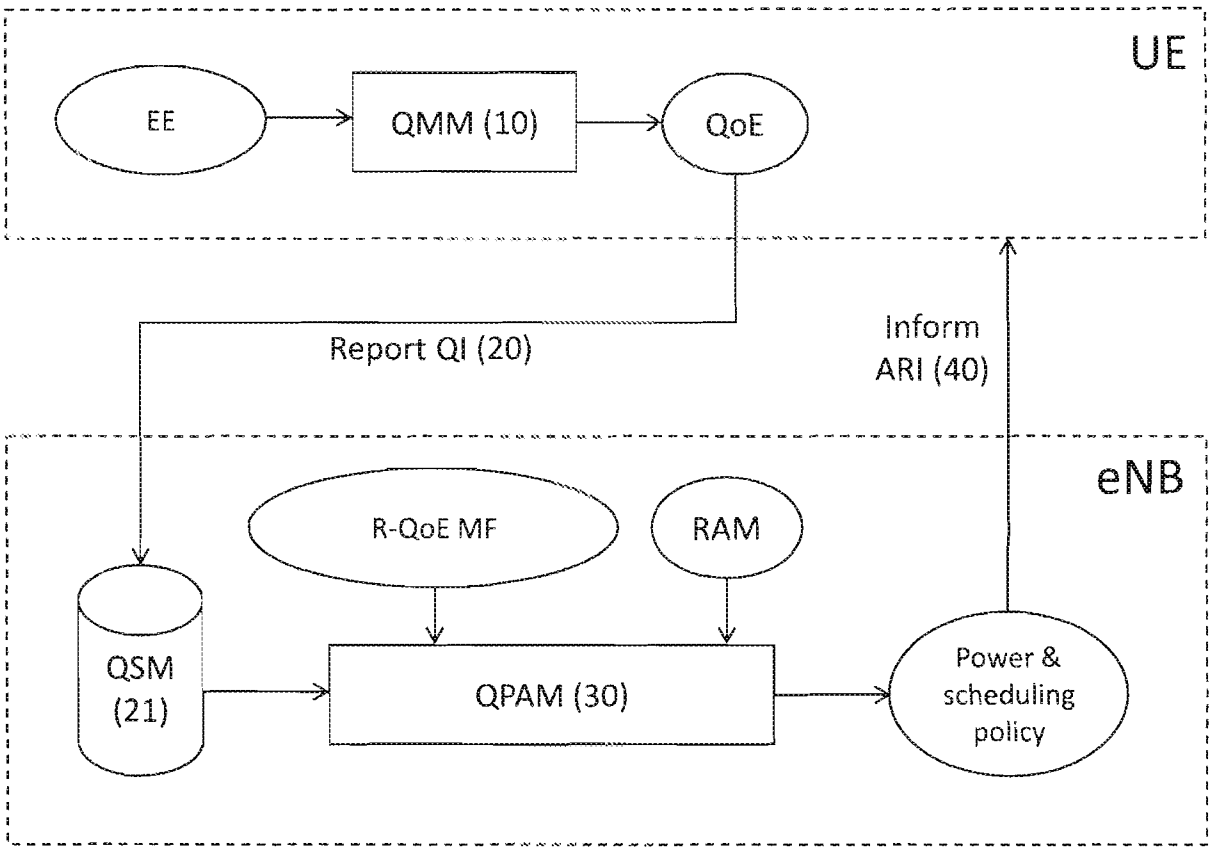

UE
EE
QMM (10)
QoE
Report QI (20)
Inform
ARI (40)
eNB
R-QoE MF
RAM
QSM
(21)
QPAM (30)
Power &
scheduling
policy

Figure 1

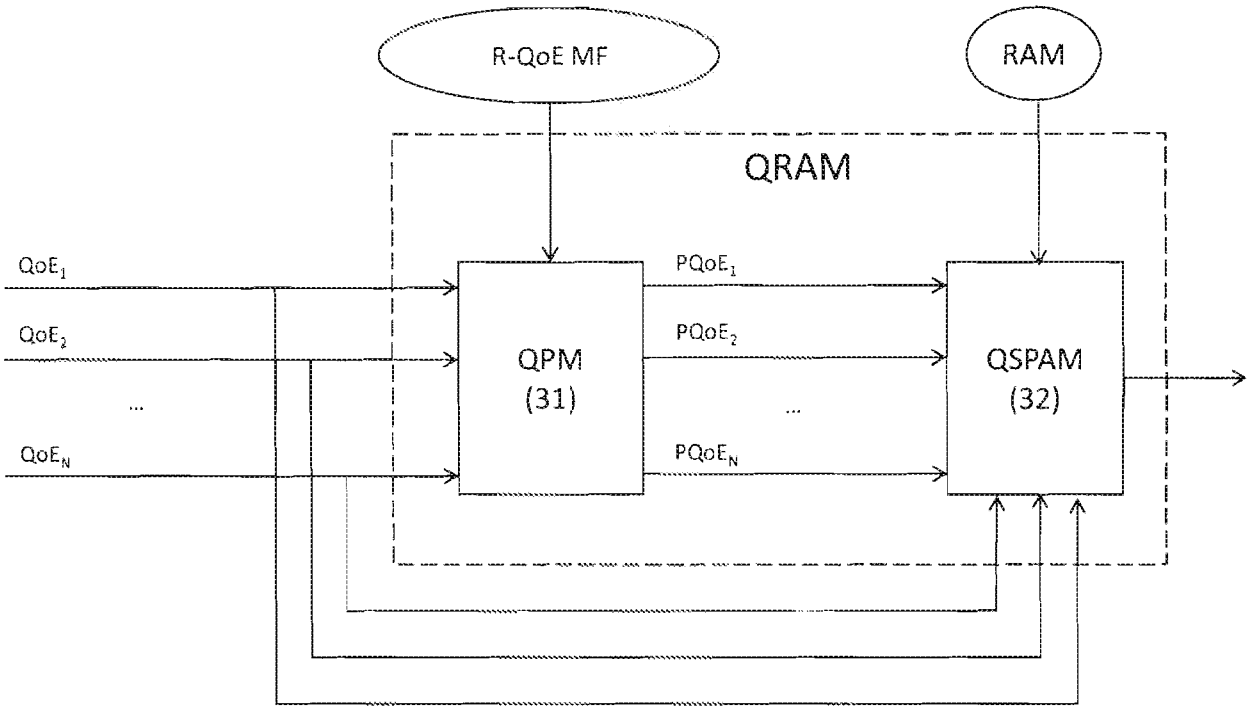

R-QoE MF
RAM
QRAM
QoE1
QoE2
...
QoEN
QPM
(31)
PQoE1
PQoE2
...
PQoEN
QSPAM
(32)

Figure 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/082304

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/00 (2009.01) i

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)

IPC: H04W 28/00, H04W28/16

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)

CPRSABS, SIPOABS, CNKI: quality, experience, QOE, resource, allocation, allocating, access point, user, UE, NB, QOS, mapping

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102291829 A (UNIV XIDIAN) 21 Dec. 2011(21.12.2011) See paragraph [0097]-[0158], figure 1	1-3, 5-13
A		4
A	US 2008155087 A1 (NORTEL NETWORKS LTD et al) 26 Jun. 2008(26.06.2008) See the entire document	1-13
A	CN102256320 A (HITACHI LTD) 23 Nov.2011(23.11.2011) See the entire document	1-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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

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"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
01 Jun. 2013 (01.06.2013)	**11 Jul. 2013 (11.07.2013)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer YI, Jian Telephone No. (86-10)62411692

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/082304

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102291829 A	21.12.2011	None	
US 2008155087 A1	26.06.2008	US 8280994 B2	02.10.2012
CN102256320 A	23.11.2011	EP 2389034 A1	23.11.2011
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