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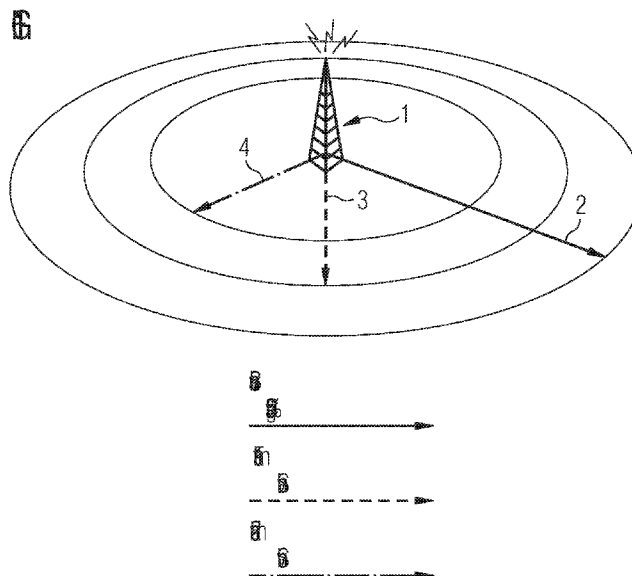
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(54) Title: A METHOD OF RESOURCE ALLOCATION FOR A BROADCAST/MULTICAST SERVICE



(57) Abstract: A method of resource allocation in a broadcast/multicast service from a network (1) to a mobile device (10) comprises splitting the service into a plurality of sub-services (2, 3, 4); allocating a session identifier to each sub-service; and allocating a service identifier to a series of sub-services forming a single service. The sub-services are synchronised according to their service identifier and session identifier; and forwarded to the mobile device. Sub-services may filtered (11) in the network according to the resources available in the cell.

A METHOD OF RESOURCE ALLOCATION FOR A BROADCAST/MULTICAST SERVICE

This invention relates to a method of resource allocation in a broadcast/multicast service from a network to a mobile device.

5 Broadcast/multicast content delivery is becoming more and more popular in wireless networks. Proof of this is the high interest shown by operators in applications like Mobile TV. However, the most requested and profitable services at present for mobile network operators (MNOs) are still voice and data. Delivering voice and data services together with broadcast/multicast services using the same share of radio
10 resources is likely to reduce the economic efficiency of the mobile network. This is because broadcast/multicast services require large amounts of resources, as compared with voice and data services and in situations where there is a lack of available resource, service blockage occurs. An example of this problem is the case of MBMS services delivery in band with other services like data and voice during periods of high
15 cell loads. Indeed, MBMS services are at present meant to be delivered at fixed bit rates regardless of the load condition of the cells forming the MBMS broadcast area.

US6014694 describes adaptive transport of video over a local area network where a bandwidth estimation is carried out and a video stream is compressed at various compression levels, then each frame is transmitted at one of the compression
20 levels, chosen according to the estimated bandwidth available.

This approach is designed for wired networks, but has a number of drawbacks in a wireless radio network. In wireless networks bandwidth estimation is unreliable, as conditions may change from the estimate to the actual transmission and estimation is undesirable, as it is carried out by loading the network, so causing congestion. Only
25 one sequence is transmitted of the compressed frame, which does not allow differentiation between different coverage areas, but to achieve maximum coverage, maximum transmission power must be used, which is not desirable in a radio network. Any loss of bandwidth during transmission using a compression method of this type will result in interruption of the service.

30 The present invention addresses the problem of resource optimisation for broadcast/multicast services, in particular in scenarios where resources are shared among multicast/broadcast and point to point services.

In accordance with a first aspect of the present invention, a method of resource allocation in a broadcast/multicast service from a network to a mobile device comprises splitting the service into a plurality of sub-services; allocating a session identifier to each sub-service; allocating a service identifier to a series of sub-services forming a
5 single service; synchronising the sub-services according to their service identifier and session identifier; and forwarding the sub-services to the mobile device.

The present invention provides the opportunity of providing broadcast/multicast services in scalable formats, so as to allow both new terminals, able to support the latest update features and legacy terminals, which are able to support only previous
10 specifications, to consume the service with appropriately scaled quality of service (QoS). The method is adaptable to varying bandwidth availability, as further filtering of quality of service enhancement information can be carried out at each node along a transmission path, so that the delivered content is still readable, even with reduced bandwidth availability. Generally, at a gateway between a wired and a wireless
15 network, there is a change in bandwidth availability, which the present invention is able to cope with.

Preferably, the method further comprises filtering the sub services according to available resources in the cell.

Preferably, the service comprises a first sub-service providing a basic quality of
20 service; and the remainder of the plurality of sub-services providing enhancement sub-services.

Each enhancement sub-service may be delivered on one radio channel, or in a different logical channel of the same radio bearer, but preferably, each enhancement sub-service is delivered on a separate radio bearer.

25 Preferably, synchronisation is carried out in the network before sending to the mobile device.

Preferably, filtering of the sub-service is carried out in the network before sending to the mobile device.

In accordance with a second aspect of the present invention, a method of
30 dynamic resource allocation in a broadcast/multicast service comprises determining a service resource requirement; dividing a broadcast area into sub-areas; determining a sustainable service bit rate in each sub-area; and delivering content to each sub-area at its sustainable bit rate.

By using different coverage areas, there is a saving in transmission power, whilst still providing a basic level of service to edge users and enhanced quality of service to users nearer to the centre of the broadcast area.

Preferably, the sustainable bit rate is less than a full bit rate.

5 Preferably, the same service identifier is applied for the same service at full bit rate and reduced bit rate.

A method according to the first aspect, further comprising the method of the second aspect.

10 An example of resource allocation according to the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrates coverage distribution for sub services forming a broadcast/multicast service according to the first aspect of the invention;

Figure 2 shows a message sequence for signalling of session identifiers belonging to sub services forming the same service according to the first aspect shown
15 in Fig 1;

Figure 3 illustrates an example of audio/video sequence decomposition in H.264; and,

Figure 4 illustrates signalling messaging for MBMS service transrating in a method of dynamic resource allocation according to the second aspect of the invention.

20

The problem of resource optimisation for broadcast/multicast of contents in scenarios where radio resources are shared by heterogeneous services mainly concerns networks with limited amounts of radio resources which are capable of delivering point
25 to multipoint, as well as point to point services. This is due point to multipoint services requiring more resources than point to point, which creates an obstacle for mass distribution of dedicated contents. In networks like digital video broadcasting terrestrial (DVB-T), digital video broadcasting handheld (DVB-H) or MediaFLO this issue is not crucial due to their high capacity and the fact that only broadcast/multicast
30 services are delivered.

However, this issue is more accentuated in cellular networks like universal mobile telecommunications system (UMTS), where broadcast/multicast services are deployed in parallel to dedicated services and where radio resources are scarce. As

deployment of broadcast/multicast services is not a commercial issue yet, a solution for optimum resource management has not been formulated to date.

The most used MBMS reference scenario at present is that where MBMS services are sent over UMTS networks in a different 5 MHz bandwidth slot with respect to services like voice and data, i.e. a 5MHz bandwidth slot is dedicated to the sole use of MBMS services and no MBMS resource optimisation is needed. Currently, the MBMS standard does not include any technique for service resource adaptation and the solution adopted in case of lack of resources is either blocking the MBMS service in the overloaded cells or (if the MBMS services is already ongoing) blocking other services.

Broadcast/multicast service are delivered according to "static" configurations where contents are either downloaded at fixed bit rates or streamed at their full encoding bit rate. If radio resources are not enough for delivery of additional point to point or point to multipoint services the service in that particular cell will be blocked.

The present invention addresses the problem of resource optimisation for broadcast/multicast services firstly by splitting the broadcast/multicast content into sub-services, hierarchically arranged. Out of these sub-services, one provides basic Quality of Service (QoS), while the remaining sub services provide enhanced levels of QoS. The higher in the hierarchy each sub service, the smaller the cell area covered by the broadcast/multicast channel assigned for transmission of the sub service. Fig. 1 gives a graphical explanation of the cell coverage for each sub service. From a transmitter 1 the basic sub service 2 provides nearly full coverage, for example, 95% coverage. The first enhancement sub-service 3 and second enhancement sub-service 4 provide reduced coverage. This reduced coverage may be the result of using a reduced transmit power, or alternatively, the same transmit power may be used for each area of coverage, but with different redundancy in the content of each transmission to have the effect of covering a different area.

Each sub service is tagged with a service ID. The network knows the set of service IDs forming the whole broadcast/multicast service and uses this information for two reasons. Firstly, to inform the terminals of which sub services appertain to the same service, so as to allow correct reception of the right content; and secondly to synchronise the different sub services with each other by means of identifying their service ID and synchronising transmission of each sub service. This is done to allow

UEs to be able to correctly reconstruct the original service from all the sub services received.

Soft combining at the cell edge is possible for each sub-service. The terminal is able to receive sub-services coming from different cells as they will be marked with the same service ID. This improves reception of sub-services covering only parts of the whole cell. As an example of the how the proposed technique can be applied, the case of MBMS services is considered, although the invention is not limited to MBMS and by replacing the UMTS nodes with devices having corresponding logical functions, the transrating technique can be applied to any type of radio network.

The “original” audio/video sequence is split into hierarchically arranged sub sequences. The centre of the cell has optimum coverage using all layers and giving maximum QoS, but towards the edge the service becomes more basic. The main sub sequence layer provides the basic QoS and is delivered in a radio bearer 2 covering a large share of the cell area, i.e. 95%. Moreover, the main sub sequence consists of audio/video content at a lower bit rate with respect to the bit rate of the original sequence, i.e. if the original sequence is encoded at 128 Kbps, the main sub sequence can have a reduced bit rate of 64 Kbps. The enhanced sub sequence layers are delivered in different radio bearers that cover only a limited portion of the cell, e.g. 66% for first enhancement layer 3, 50% for second enhancement layer 4, etc., as illustrated in Fig 1. MBMS allows for edge combining, so coverage in the first enhancement layer can be extended in this way.

The network and in particular, a radio network controller (RNC) in the network is able to filter sub-services if resources available in the cell are not sufficient to deliver the entire set of sub services. Sub-services to be filtered out are the enhancement layers starting from the least important in the hierarchy and going gradually up to the most important. By combining filtering of sub-services with deployment of hierarchically arranged sub-services with different cell coverage, the combination as a whole provides highly scalable methods of optimising resource utilisation and counter-reacting to cell congestion when deploying broadcast/multicast services. The invention improves radio resource efficiency for MBMS services as average transmission power used by all transmissions, is less than sending in only one bearer able to cover the whole cell.

Each sub sequence layer has a unique session identifier, or temporary multicast group identity (TMGI) and shares the same service identifier as other sub services

forming the same full rate service. The sub services are bundled together at the RNC by means of opportune tagging and signalling from a broadcast multicast service centre (BM-SC). This allows UEs to detect all the sub sequences forming the service. Also, having different session IDs for each sub service allows cell edge soft combining of each broadcast/multicast channel containing a sub service. Sub services can be filtered at the RNC depending on resources available in the cell. Enhancement sub services are combined with the main sub sequence at the UE, and so need to have a certain level of synchronisation with each other and with the main sub sequence. This can be achieved by synchronising the start of the play out, at the RNC, of each sub sequence on the basis of sub-sequence session IDs.

Signalling between the BM-SC and the RNC for sub-services bundling is illustrated in Fig 2. At the BM-SC 5, sub-services are created with TMGI and session IDs generation 6, then a group of session IDs forming an MBMS service is signalled 7 to the RNC. The RNC 8 signals 9 the group of session IDs forming the MBMS service to a broadcast group of UEs 10, on broadcast control channels. The UEs send session IDs group reception acknowledgements 10A and at the RNC 8, sub-service transmission start synchronisation 11 is based on the session IDs identification and sub services filtering is based on available cell resources. The RNC then sends a synchronised transmission 12 of the sub-services to the UEs. For MBMS audio/video services the standardised codec is H.264. This codec allows for “splitting” of audio/video sequences in hierarchically dependent sub sequences.

Figure 3 shows how H.264 can decompose a sequence into sub sequences as the video codec in MBMS allows splitting a video sequence into layers. The figure shows an example of a Group of Pictures (GOP) where pictures are categorized into three sub-sequence layers. Boxes indicate frames, letters in boxes indicate frame types, numbers in boxes indicate frame numbers, dashed ellipses indicate sub-sequences, vertical alignment of boxes indicate the sub-sequence layer which the picture belongs to, arrows indicate prediction dependencies, and display time runs from left to right. The top horizontal layer is the basic layer, the rest are enhancement layers. The terminal can decode after receiving the basic layers and access the basic service. The other layers, but only when received in the correct order, allow reconstruction and enhancement of quality of sequence. A first sub-sequence is made up of sequence frames I0, P1, P3, P5 with prediction dependencies to further sequence frames B2, B4,

B6, B8. Sequence B2, B4, B6, B8 represents the first enhancement layer and can only be decoded once the basic layer is decoded. The last enhancement layer in the hierarchy is formed by frames B3, B5, B7 and B9. In order for the last enhancement layer to be decoded all the other layers need to have been received correctly.

5 Scalable audio/video codec, for example H.264 for multicast/broadcast of streaming services, has been proposed. This allows the encoder to strip hierarchically arranged layers of information from the main stream in order to adapt the content to the operator's need. However, this does not take into account the problem of dynamically changing resources available in a wireless network, but is mainly designed for adapting
10 the content to prescheduled network setups. Transrating has been used in the past along the same line, being used as a technique to adapt the content to the type of network and to the prescheduled bit rate planned by the operator for a particular service. However, transrating has not been used so far to adapt the content characteristics to the available resources on the basis of a dynamic estimation of the
15 "affordable" service bit rate, i.e. adapted to the particular resource characteristics of the network.

Fig. 4 provides an illustration of a further aspect of the present invention which deals with situations where dynamic resource allocation is required to address problems of insufficient resource availability. The RNC 8 analyses 13 the available resources in
20 each cell forming the broadcast service area and, if the amount of resource requested by the MBMS service overwhelms, or cannot be obtained from, the available resources in one or more cells forming a broadcast service area, then the RNC determines 14 one or more broadcast service sub-areas, i.e. sub groups of cells with only limited resources, and a sustainable MBMS service bit rate for each of those sub groups.

25 The RNC requests a transrated stream for broadcast service areas by signalling 15 the broadcast service sub-areas, together with the respective decreased service bit rate, to the BM-SC 5 asking for a down-rated version of the streaming content to be delivered to the broadcast service sub-areas. The BM-SC generates down-rated streams (with the same MBMS Service ID of the full rate service) according to the
30 information sent from the RNC and delivers 16, 17, 18 each of them to the opportune broadcast service sub-area 1 to n 19, 20.

The down rated services are delivered with the same MBMS Service ID as the full rate service. This is because if a UE moves, for example from one cell supporting

reduced bit rate to a cell supporting full bit rate the UE does not need to search for a service with a new MBMS Service ID, but it can keep on listening to the same MBMS Service ID and experience an improved QoS.

Thus the present invention allows efficient radio resource utilisation, by
5 allowing decomposition of broadcast/multicast services into multiple hierarchically-
dependent sub-services and enabling broadcasting of such sub-services in areas scaled
down depending on the degree of hierarchy of the sub services, so that the overall
transmission power dedicated to the transmission of the entire group of sub services is
reduced with respect to the power required for broadcasting the service as a whole. In
10 cellular networks like UMTS, this means less radio resources are required for the
service transmission. Further, the possibility of filtering sub-services in case of limited
availability of resources in the cell, allows for avoiding service blocking at the expense
of lower cell coverage.

Further, the adoption of opportune methods for tagging each sub service (e.g.
15 choice of session IDs, or TMGIs) allows sub service synchronisation and cell edge soft
combining, which can allow correct reception of high QoS levels in extended cell areas.

The additional feature of multicast/broadcast content transrating allows for
dynamically controlling the resources needed by multicast/broadcast services. This
allows multicast/broadcast services to coexist together with other services like data and
20 voice, without the risk to either of these services of being blocked due to lack of cell
resources. The content downrating feature does not affect perceived QoS on streaming
video services if performed within certain limits. Indeed, modern audio/video
transcoders are able to modify audio/video content bit rate on the fly without any
change in perceived QoS if the down rating is limited to a maximum of around 20%.
25 Therefore, if a full MBMS audio/video streaming service bit rate is supposed to be 256
Kbps a down rated version of the service should not have bit rate lower than 200 Kbps
(limit depending on minimum target QoS). This means that during peak load times a
cell can gain resources for up to five voice call services for each fully down rated
MBMS streaming service, improving the economical efficiency of the platform.

30 Another advantage of the invention is that it adapts to possible evolution of
terminals and networks. Indeed, terminals and network may evolve in a way to support
enhanced QoS (e.g. by supporting higher bit rates) or transmission modes (i.e. by
enabling new radio bearers). This invention still allows legacy terminals to receive and

consume broadcast/multicast services delivered in enhanced modes. This is because the services are designed so as to have the first sub services in the hierarchy (providing basic/medium QoS) are delivered on radio bearers receivable by legacy terminals (i.e. Release 6 UEs for UMTS), while the enhancement sub services (providing top QoS) are delivered via new radio bearers and receivable by new terminal releases (i.e. Release 7 UEs for UMTS).

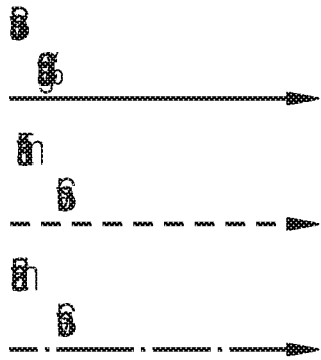
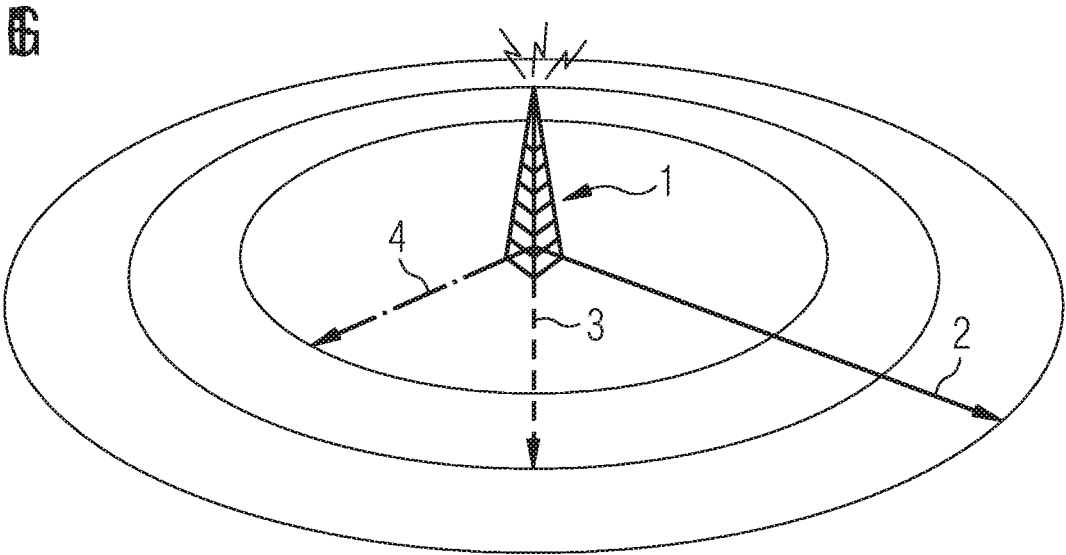
In the MBMS bearer context set up for multiple sessions of same service, they are given the same service id, but different session id. The node responsible for content distribution in the cellular network (i.e. BM-SC in UMTS) labels the components of the service and communicates the service and session ids of each component to a radio access gateway, then the gateway does synchronisation. Before duplicating and sending, synchronisation for transmission to the nodeB is applied. The UE buffer can only compensate for small misalignment within 1 second. The invention saves radio resources in audio/video services, as the average transmission power is lower than sending full rate in one bearer. The use of multiple bearers for service splitting is based on a static layout, which gives it robustness and it is not dependent on network events, whereas the second aspect of the invention provides a dynamic solution, whereby before sending the MBMS, the RNC analyses the resources of each cell under its control and if resources are not sufficient, then the RNC groups cells without sufficient resource according to the level of resource that is available. There is no increase in complexity at the application layer of the UE. The content is transrated, but is otherwise the same, apart from having a lower bit rate. Thus, there is provided a dynamic solution to allow the network to adapt to new situations of congestion.

By contrast with the methods of the prior art the content delivered by the content data source does not consist of one sequence of application data frames compressed in the most suitable estimated format but it consists of a multitude of sub-streams hierarchically organised (see Figure 3), each of them compressed in a different way, transmitted on different, concentric, coverage areas so that the terminal receiving them can combine them together and achieve a quality of service proportionally improving with the number of sub-services correctly received, decoded and combined.

CLAIMS

1. A method of resource allocation in a broadcast/multicast service from a network to a mobile device; the method comprising splitting the service into a plurality of sub-services; allocating a session identifier to each sub-service; allocating a service identifier to a series of sub-services forming a single service; synchronising the sub-services according to their service identifier and session identifier; and forwarding the sub-services to the mobile device.
2. A method according to claim 1, wherein the method further comprises filtering the sub-services according to available resources in the cell,
3. A method according to claim 1 or claim 2, wherein the service comprises a first sub-service providing a basic quality of service; and the remainder of the plurality of sub-services providing enhancement sub-services.
4. A method according to claim 3, wherein each enhancement sub-service is delivered on a separate radio bearer.
5. A method according to any preceding claim, wherein synchronisation is carried out in the network before sending to the mobile device.
6. A method according to any preceding claim, wherein filtering of the sub service is carried out in the network, before sending to the mobile device.
7. A method of dynamic resource allocation in a broadcast/multicast service, the method comprising determining a service resource requirement; dividing a broadcast area into sub-areas; determining a sustainable service bit rate in each sub-area; and delivering content to each sub-area at its sustainable bit rate.
8. A method according to claim 7, wherein the sustainable bit rate is less than a full bit rate.

9. A method according to claim 8, wherein the same service identifier is applied for the same service at full bit rate and reduced bit rate.
10. A method according to any of claims 1 to 6, further comprising the method of
5 any of claims 7 to 9.



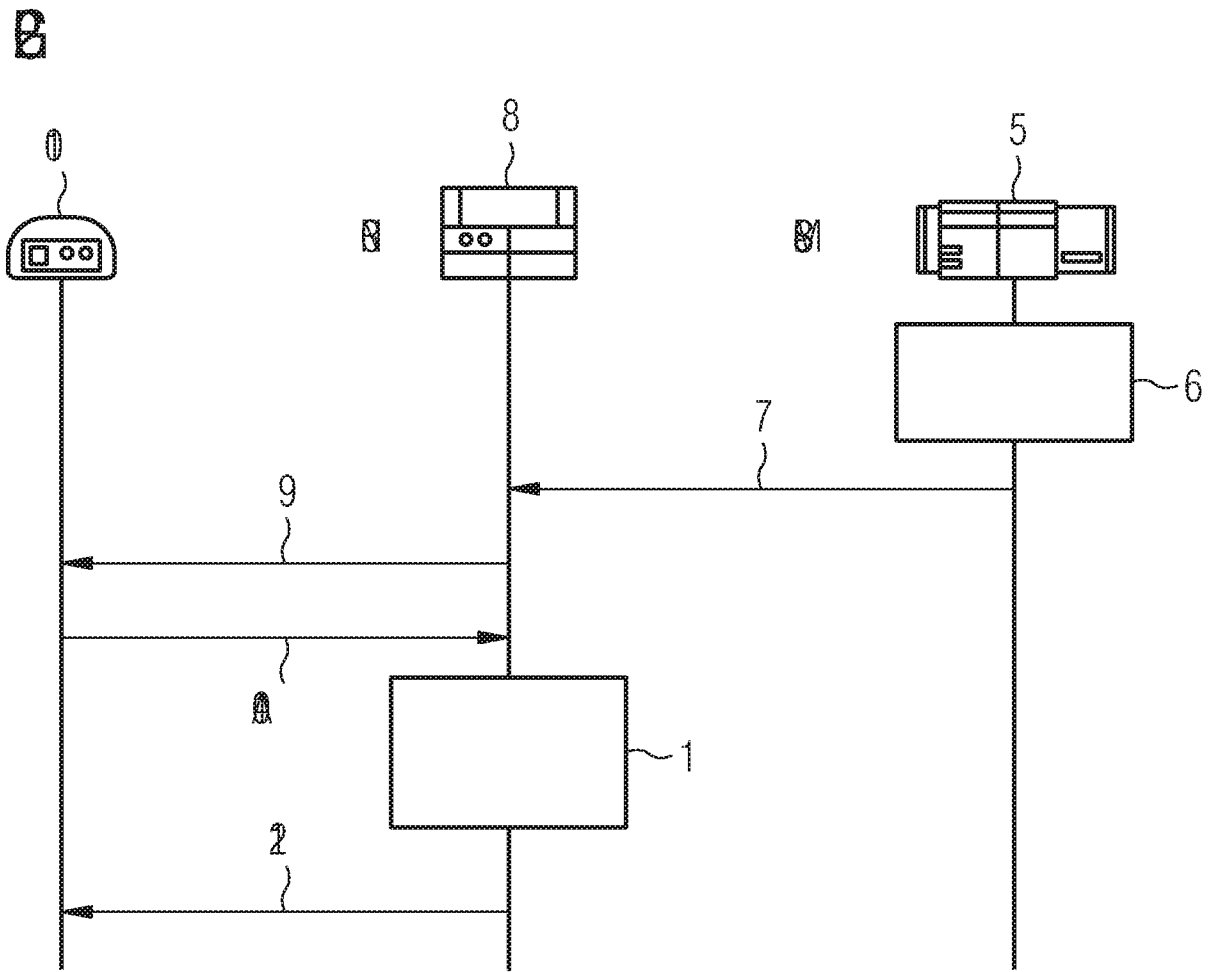
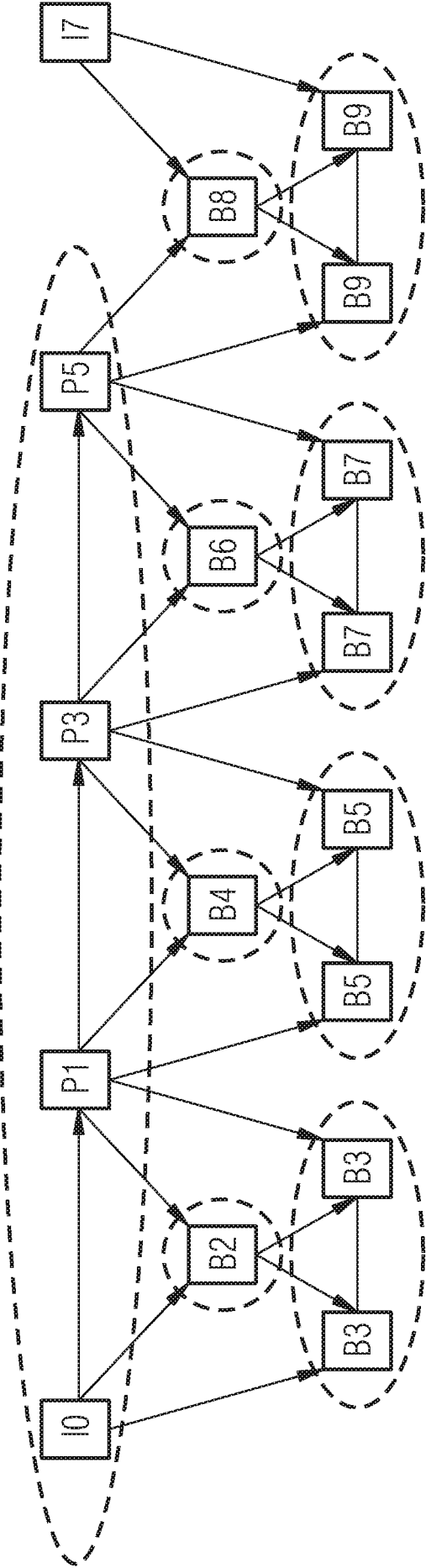
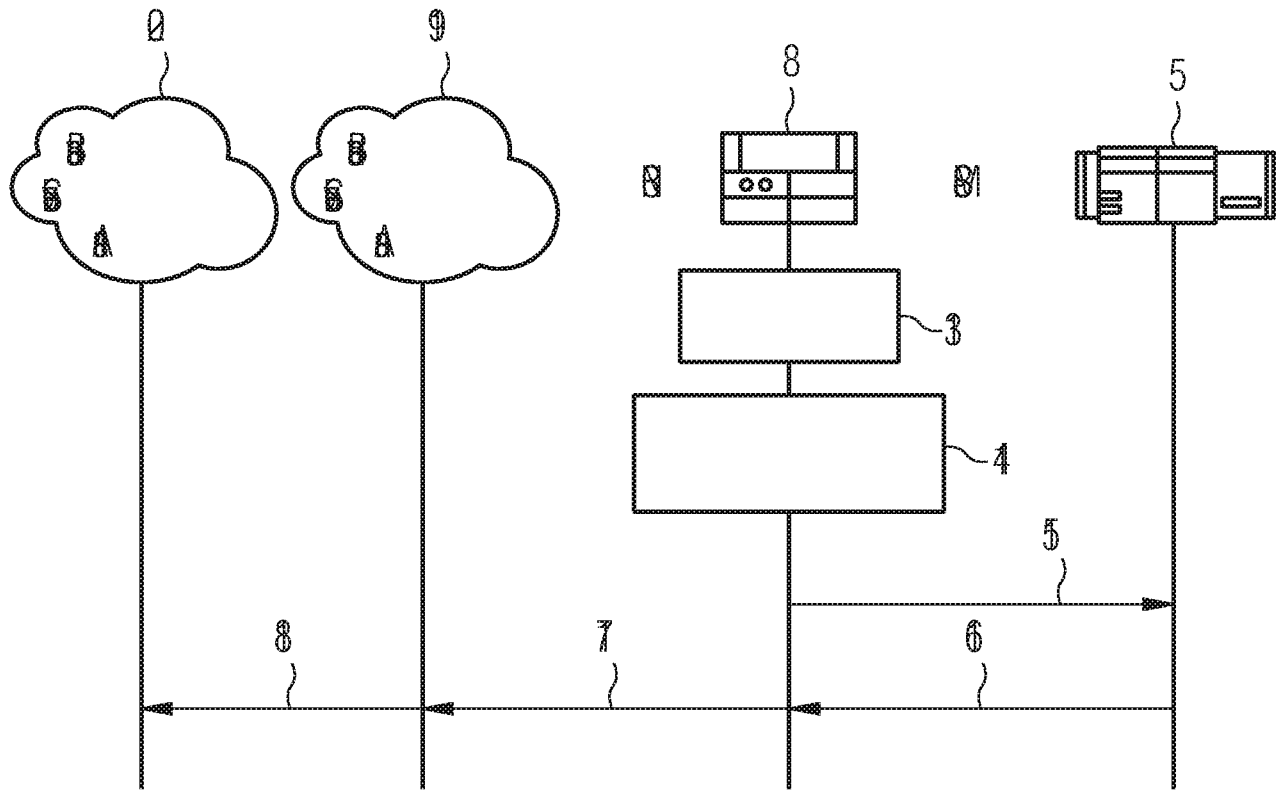


FIG 3



4



INTERNATIONAL SEARCH REPORT

 International application No
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 A. CLASSIFICATION OF SUBJECT MATTER
 INV. H04L12/18 H04Q7/38

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L H04Q

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 610 502 A (MATSUSHITA ELECTRIC IND CO LTD [JP]) 28 December 2005 (2005-12-28) paragraph [0063] - paragraph [0065] paragraph [0084] paragraph [0085] paragraph [0138] - paragraph [0149] paragraph [0154] - paragraph [0156]	1-10
X	EP 1 670 263 A1 (HUAWEI TECH CO LTD [CN]) 14 June 2006 (2006-06-14) paragraph [0039] - paragraph [0041]	7-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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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

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& document member of the same patent family

Date of the actual completion of the international search

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Ströbeck, Anders

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 1610502	A	28-12-2005	CN 1998195 A WO 2005125118 A1	11-07-2007 29-12-2005
EP 1670263	A1	14-06-2006	CA 2540983 A1 WO 2005053331 A1 CN 1617615 A JP 2007511937 T	09-06-2005 09-06-2005 18-05-2005 10-05-2007