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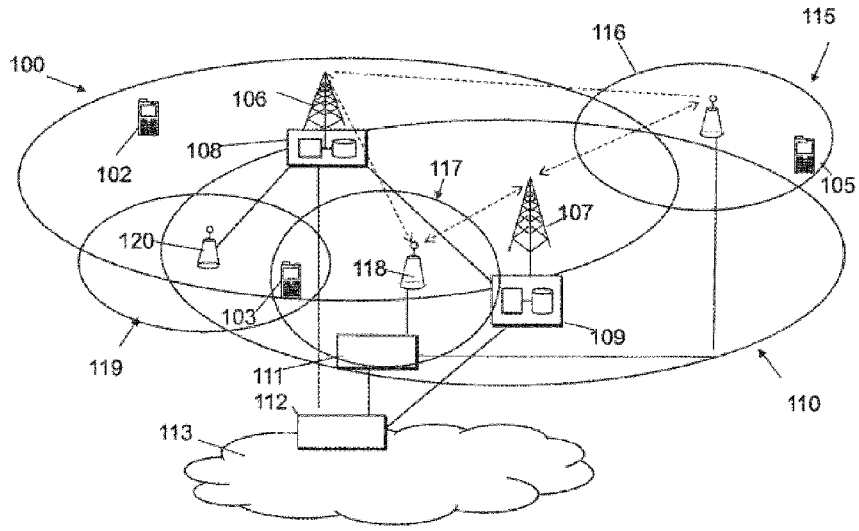
(54) Title: METHOD, APPARATUS AND COMPUTER PROGRAM

Figure 1



(57) Abstract: A method comprising: determining if a cell can accommodate a traffic flow, said determining based upon a target quality of service for users of said cell and a measured quality of service for users of said cell; and steering said traffic flow to or away from said cell in dependence on said determination.

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Method, apparatus and computer program

The present invention relates to a method, apparatus and computer program for traffic steering.

A communication system can be seen as a facility that enables communication sessions between two or more entities such as fixed or mobile communication devices, base stations, servers and/or other communication nodes. A communication system, and compatible communicating entities, typically operate in accordance with a given standard or specification which sets out what the various entities associated with the system are permitted to do and how that should be achieved. For example, the standards, specifications and related protocols can define the manner how various aspects of communication shall be implemented between communicating devices. A communication can be carried on wired or wireless carriers. In a wireless communication system at least a part of communications between stations occurs over a wireless link.

Examples of wireless systems include public land mobile networks (PLMN) such as cellular networks, satellite based communication systems and different wireless local networks, for example wireless local area networks (WLAN). A wireless system can be divided into cells or other radio coverage or service areas. A radio service area is provided by a station. Radio service areas can overlap, and thus a communication device in an area can typically send signals to and receive signals from more than one station.

A user can access the communication system by means of an appropriate communication device. A communication device of a user is often referred to as user equipment (UE) or terminal. A communication device is provided with an appropriate signal receiving and transmitting arrangement for enabling communications with other parties. Typically a communication device is used for enabling receiving and transmission of communications such as speech and data. In wireless systems a communication device provides a transceiver station that can communicate with another communication device such as e.g. a base station or an access point and/or

another user equipment. The communication device may access a carrier provided by a station, for example a base station or an access node, and transmit and/or receive communications on the carrier.

An example of communication systems is an architecture that is being standardized by the 3rd Generation Partnership Project (3GPP). This system is often referred to as the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. A further development of the LTE is often referred to as LTE-Advanced. The various development stages of the 3GPP LTE specifications are referred to as releases.

A communication system can comprise different types of radio service areas providing transmission/reception points for the users. For example, in LTE-Advanced the transmission/reception points can comprise wide area network nodes such as a macro eNode-B (eNB) which may, for example, provide coverage for an entire cell or similar radio service area. Network nodes can also be small or local radio service area network nodes, for example Home eNBs (HeNB), pico eNodeBs (pico-eNB), or femto nodes. Some applications utilise radio remote heads (RRH) that are connected to for example an eNB. The smaller radio service areas can be located wholly or partially within the larger radio service area. A user equipment may thus be located within, and thus communicate with, more than one radio service area. The nodes of the smaller radio service areas may be configured to support local offload. The local nodes can also, for example, be configured to extend the range of a cell.

According to one aspect there is provided a method comprising: determining if a cell can accommodate a traffic flow, said determining based upon a target quality of service for users of said cell and an measured quality of service for users of said cell; and steering said traffic flow to or away from said cell in dependence on said determination.

Preferably said determining comprises comparing said target quality of service to said measured quality of service.

Preferably said measured quality of service is at least partially determined from parameters of a traffic flow.

Preferably said parameters are comprised in a Packet Data Protocol context.

Preferably said parameters are comprised in an Evolved Packet System bearer.

Preferably said parameters are obtained by deep packet inspection of said traffic flow.

Preferably said target quality of service is obtained from operator quality of service policy.

Preferably said operator quality of service policy is one of: stored in memory; retrieved from a node.

Preferably said determining comprises obtaining user information from a home subscriber server or home location register.

Preferably if it is determined that said cell can accommodate said traffic flow said traffic flow is steered to said cell.

Preferably, if it is determined that said cell cannot accommodate said traffic flow, then said traffic flow is steered away from said cell.

Preferably said determining is carried out in an operation support system node.

According to a second aspect there is provided a method comprising: determining, at a node, if a cell at least partially controlled by said node can accommodate a traffic flow, said determining based upon a target quality of service for users of said cell and a measured quality of service for users of said cell; and steering said traffic flow to or away from said cell in dependence on said determination.

Preferably said determining comprises comparing said target quality of service to said measured quality of service.

Preferably said measured quality of service is at least partially determined from parameters of a traffic flow.

Preferably said parameters are comprised in a Packet Data Protocol context.

Preferably said parameters are comprised in an Evolved Packet System bearer.

Preferably said parameters are obtained by deep packet inspection of said traffic flow.

Preferably said target quality of service is obtained from operator quality of service policy.

Preferably said operator quality of service policy is one of: stored in memory; retrieved from a node.

Preferably said determining comprises obtaining user information from a home subscriber server or home location register.

Preferably if it is determined that said cell can accommodate said traffic flow said traffic flow is steered to said cell.

Preferably, if it is determined that said cell cannot accommodate said traffic flow, then said traffic flow is steered away from said cell.

Preferably said node is configured to send an update message to a further node confirming that said traffic flow has been steered to or away from said cell.

Preferably said node comprises a base station.

According to a third aspect there is provided a method comprising: configuring a cell to operate in one of a traffic-steering mode and a non traffic-steering mode; and using quality of service information associated with said configured mode for use in said configured mode.

Preferably said cell is configured to operate in said non traffic-steering mode when a measured quality of service for users in said cell meets a first pre-determined quality of service level.

Preferably said cell is configured to operate in said traffic-steering mode when a measured quality of service for users in said cell meets a second pre-determined quality of service level.

Preferably said first pre-determined quality of service level may be altered.

Preferably said second pre-determined quality of service level may be altered.

Preferably when said cell is in said traffic-steering mode, said traffic is steered to a second cell.

Preferably said configuring is carried out by an operation support system node.

According to a fourth aspect there is provided a computer program comprising computer executable instructions which when run on one or more processors perform the method as discussed above.

According to a fifth aspect there is provided an apparatus; wherein said apparatus is configured to determine if a cell can accommodate a traffic flow based upon a target quality of service for users of said cell and a measured quality of service for users of said cell; and wherein said apparatus is configured to steer said traffic flow to or away from said cell in dependence on said determination.

Preferably said apparatus is configured to compare said target quality of service to said measured quality of service.

Preferably said apparatus is configured to at least partially determine said measured quality of service from parameters of a traffic flow.

Preferably said parameters are comprised in a Packet Data Protocol context.

Preferably said parameters are comprised in an Evolved Packet System bearer.

Preferably said apparatus is configured to obtain said parameters by deep packet inspection of said traffic flow.

Preferably said apparatus is configured to obtain said target quality of service from operator quality of service policy.

Preferably said operator quality of service policy is one of: stored in memory; retrieved from a node.

Preferably said apparatus is configured to obtain user information from a home subscriber server or home location register for use in said determining.

Preferably if it is determined that said cell can accommodate said traffic flow said apparatus is configured to steer said traffic flow to said cell.

Preferably, if it is determined that said cell cannot accommodate said traffic flow, then said apparatus is configured to steer said traffic flow away from said cell.

Preferably said apparatus comprises an operation support system node.

According to a sixth aspect there is provided an apparatus; wherein said apparatus is configured to determine if a cell at least partially controlled by said apparatus can accommodate a traffic flow based upon a target quality of service for users of said

cell and a measured quality of service for users of said cell; and wherein said apparatus is configured to steer said traffic flow to or away from said cell in dependence on said determination.

Preferably said apparatus is configured to compare said target quality of service to said measured quality of service.

Preferably said apparatus is configured to at least partially determine said measured quality of service from parameters of a traffic flow.

Preferably said parameters are comprised in a Packet Data Protocol context.

Preferably said parameters are comprised in an Evolved Packet System bearer.

Preferably said apparatus is configured to obtain said parameters by deep packet inspection of said traffic flow.

Preferably said apparatus is configured to obtain said target quality of service from operator quality of service policy.

Preferably said operator quality of service policy is one of: stored in memory; retrieved from a node.

Preferably said apparatus is configured to obtain user information from a home subscriber server or home location register for use in said determining.

Preferably said apparatus is configured to steer said traffic flow to said cell if it is determined that said cell can accommodate said traffic flow.

Preferably, if said cell cannot accommodate said traffic flow, then said apparatus is configured to steer said traffic flow away from said cell.

Preferably said apparatus is configured to send an update message to a further apparatus confirming that said traffic flow has been steered to or away from said cell.

Preferably said apparatus comprises a base station.

According to a seventh aspect there is provided an apparatus; wherein said apparatus is configured to configure a cell to operate in one of a traffic-steering mode and a non traffic-steering mode; and wherein said apparatus is configured to use quality of service information associated with said configured mode for use in said configured mode.

Preferably said apparatus is configured to operate said cell in said non traffic-steering mode when a measured quality of service for users in said cell meets a first pre-determined quality of service level.

Preferably said apparatus is configured to operate said cell in said traffic-steering mode when a measured quality of service for users in said cell meets a second pre-determined quality of service level.

Preferably said apparatus is configured to alter said first pre-determined quality of service level.

Preferably said apparatus is configured to alter said second pre-determined quality of service level.

Preferably when said cell is in said traffic-steering mode, said apparatus is configured to steer said traffic to a second cell.

Preferably said apparatus comprises an operation support system node.

According to an eighth aspect there is provided an apparatus; wherein said apparatus comprises means for determining if a cell can accommodate a traffic flow based upon a target quality of service for users of said cell and a measured quality of

service for users of said cell; and wherein said apparatus comprises means for steering said traffic flow to or away from said cell in dependence on said determination.

Preferably said apparatus comprises means for comparing said target quality of service to said measured quality of service.

Preferably said apparatus comprises means for at least partially determining said measured quality of service from parameters of a traffic flow.

Preferably said parameters are comprised in a Packet Data Protocol context.

Preferably said parameters are comprised in an Evolved Packet System bearer.

Preferably said apparatus comprises means for obtaining said parameters by deep packet inspection of said traffic flow.

Preferably said apparatus comprises means for obtaining said target quality of service from operator quality of service policy.

Preferably said operator quality of service policy is one of: stored in memory; retrieved from a node.

Preferably said apparatus comprises means for obtaining user information from a home subscriber server or home location register for use in said determining.

Preferably said apparatus comprises means for steering said traffic flow to said cell when it is determined that said cell can accommodate said traffic flow.

Preferably said apparatus comprises means for steering said traffic flow to another cell if it is determined that said cell cannot accommodate said traffic flow.

Preferably said apparatus comprises an operation support system node.

According to a ninth aspect there is provided an apparatus; wherein said apparatus comprises means for determining if a cell at least partially controlled by said apparatus can accommodate a traffic flow based upon a target quality of service for users of said cell and a measured quality of service for users of said cell; and wherein said apparatus comprises means for steering said traffic flow to or away from said cell in dependence on said determination.

Preferably said apparatus comprises means for comparing said target quality of service to said measured quality of service.

Preferably said apparatus comprises means for at least partially determining said measured quality of service from parameters of a traffic flow.

Preferably said parameters are comprised in a Packet Data Protocol context.

Preferably said parameters are comprised in an Evolved Packet System bearer.

Preferably said apparatus comprises means for obtaining said parameters by deep packet inspection of said traffic flow.

Preferably said apparatus comprises means for obtaining said target quality of service from operator quality of service policy.

Preferably said operator quality of service policy is one of: stored in memory; retrieved from a node.

Preferably said apparatus comprises means for obtaining user information from a home subscriber server or home location register for use in said determining.

Preferably said apparatus comprises means for steering said traffic flow to said cell if it is determined that said cell can accommodate said traffic flow.

Preferably said apparatus comprises means for steering said traffic flow away from said cell if it is determined that said cell cannot accommodate said traffic flow.

Preferably said apparatus comprises means for sending an update message to a further apparatus confirming that said traffic flow has been steered to or away from said cell.

Preferably said apparatus comprises a base station.

According to a tenth aspect there is provided an apparatus comprising means for configuring a cell to operate in one of a traffic-steering mode and a non traffic-steering mode; and wherein said apparatus comprises means for using quality of service information associated with said configured mode for use in said configured mode.

Preferably said apparatus comprises means for configuring said cell to operate in said non traffic-steering mode when a measured quality of service for users in said cell meets a first pre-determined quality of service level.

Preferably said apparatus comprises means for configuring said cell to operate in said traffic-steering mode when a measured quality of service for users in said cell meets a second pre-determined quality of service level.

Preferably said apparatus comprises means for altering said first pre-determined quality of service level.

Preferably said apparatus comprises means for altering said second pre-determined quality of service level.

Preferably said apparatus comprises means for steering said traffic to a second cell when said cell is in said traffic-steering mode.

Preferably said apparatus comprises an operation support system node.

According to an eleventh aspect there is provided a system comprising: an apparatus configured to determine if a cell can accommodate a traffic flow based upon a target quality of service for users of said cell and a measured quality of service for users of said cell; and wherein said apparatus is configured to steer said traffic flow to or away from said cell in dependence on said determination.

Some embodiments will now be described by way of example only with reference to the accompanying figures in which:

Figure 1 shows a schematic diagram of a network according to some embodiments;

Figure 2 shows a schematic diagram of a mobile communication device according to some embodiments;

Figure 3 shows a schematic diagram of a control apparatus according to some embodiments;

Figure 4 is a flow chart showing steps of a traffic steering procedure;

Figure 5 shows an exemplary set of cells.

In the following certain exemplifying embodiments are explained with reference to a wireless or mobile communication system serving mobile communication devices. Before explaining in detail the exemplifying embodiments, certain general principles of a wireless communication system and mobile communication devices are briefly explained with reference to Figures 1 to 3 to assist in understanding the technology underlying the described examples.

In a wireless communication system mobile communication devices or user equipments (UE) 102, 103, 105 are provided wireless access via at least one base

station or similar wireless transmitting and/or receiving node or point. In the Figure 1 example two overlapping access systems or radio service areas of a cellular system 100 and 110 and three smaller radio service areas 115, 117 and 119 provided by base stations 106, 107, 116, 118 and 120 are shown. Each mobile communication device and station may have one or more radio channels open at the same time and may send signals to and/or receive signals from more than one source. It is noted that the radio service area borders or edges are schematically shown for illustration purposes only in Figure 1. It shall also be understood that the sizes and shapes of radio service areas may vary considerably from the shapes of Figure 1. A base station site can provide one or more cells. A base station can also provide a plurality of sectors, for example three radio sectors, each sector providing a cell or a subarea of a cell. All sectors within a cell can be served by the same base station.

Base stations are typically controlled by at least one appropriate controller apparatus so as to enable operation thereof and management of mobile communication devices in communication with the base stations. In Figure 1 control apparatus 108 and 109 is shown to control the respective macro level base stations 106 and 107. The control apparatus of a base station can be interconnected with other control entities. The control apparatus is typically provided with memory capacity and at least one data processor. The control apparatus and functions may be distributed between a plurality of control units.

In Figure 1 stations 106 and 107 are shown as connected to a wider communications network 113 via gateway 112. A further gateway function may be provided to connect to another network. The smaller stations 116, 118 and 120 can also be connected to the network 113, for example by a separate gateway function and/or via the controllers of the macro level stations. In the example, stations 116 and 118 are connected via a gateway 111 whilst station 120 connects via the controller apparatus 108.

A possible mobile communication device for transmitting and retransmitting information blocks towards the stations of the system will now be described in more detail with reference to Figure 2 showing a schematic, partially sectioned view of a

communication device 102. Such a communication device is often referred to as user equipment (UE) or terminal. An appropriate mobile communication device may be provided by any device capable of sending and receiving radio signals. Non-limiting examples include a mobile station (MS) such as a mobile phone or what is known as a 'smart phone', a computer provided with a wireless interface card or other wireless interface facility, personal data assistant (PDA) provided with wireless communication capabilities, or any combinations of these or the like. A mobile communication device may provide, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and so on. Users may thus be offered and provided numerous services via their communication devices. Non-limiting examples of these services include two-way or multi-way calls, data communication or multimedia services or simply an access to a data communications network system, such as the Internet. Users may also be provided broadcast or multicast data. Non-limiting examples of the content include downloads, television and radio programs, videos, advertisements, various alerts and other information. The mobile device 102 may receive signals over an air interface 207 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 2 transceiver apparatus is designated schematically by block 206. The transceiver apparatus 206 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the mobile device.

A wireless communication device can be provided with a Multiple Input / Multiple Output (MIMO) antenna system. MIMO arrangements as such are known. MIMO systems use multiple antennas at the transmitter and receiver along with advanced digital signal processing to improve link quality and capacity. Although not shown in Figures 1 and 2, multiple antennas can be provided, for example at base stations and mobile stations, and the transceiver apparatus 206 of Figure 2 can provide a plurality of antenna ports. More data can be received and/or sent where there are more antenna elements. A station may comprise an array of multiple antennas. Signalling and muting patterns can be associated with Tx antenna numbers or port numbers of MIMO arrangements.

A mobile device is also typically provided with at least one data processing entity 201, at least one memory 202 and other possible components 203 for use in software and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 204. The user may control the operation of the mobile device by means of a suitable user interface such as key pad 205, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 208, a speaker and a microphone can be also provided. Furthermore, a mobile communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto.

Figure 3 shows an example of a control apparatus for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a base station. In some embodiments the control apparatus may be part of a base station. In some embodiments base stations comprise a separate control apparatus. In other embodiments the control apparatus can be another network element. The control apparatus 109 can be arranged to provide control on communications in the service area of the system. The control apparatus 109 can be configured to provide control functions in association with generation and communication of request and instructions in view of reception of information blocks, retransmissions and other related information by means of the data processing facility in accordance with certain embodiments described below. For this purpose the control apparatus 109 comprises at least one memory 301, at least one data processing unit (or processor or microprocessor) 302, 303 and an input/output interface 304. Via the interface the control apparatus can be coupled to a receiver and a transmitter. The receiver and/or transmitter may be part of a base station. That is the apparatus may comprise means for receiving and means for sending/transmitting. The control apparatus 109 can be configured to execute an appropriate software code to provide the control functions. It shall be appreciated that similar components can be provided in a

control apparatus provided elsewhere in the system for controlling reception of sufficient information for decoding of received information blocks.

Although Figure 3 shows one memory 301 and two processors 302 and 303, any number of these components may be provided. Multiple functions may be carried out in a single processor, or separate functions may be carried out by separate processors. For example a single processor may be used to make multiple determinations, or separate determinations may be made by separate processors.

The communication devices 102, 103, 105 can access the communication system based on various access techniques, such as code division multiple access (CDMA), or wideband CDMA (WCDMA). Other examples include time division multiple access (TDMA), frequency division multiple access (FDMA) and various schemes thereof such as the interleaved frequency division multiple access (IFDMA), single carrier frequency division multiple access (SC-FDMA) and orthogonal frequency division multiple access (OFDMA), space division multiple access (SDMA) and so on.

Referring back to Figure 1, each UE 102, 103, 105 may be controlled by any of base stations 106, 107, 116, 118 or 120. In some embodiments a UE may connect to the base station with the best radio channels. In another embodiment the UE may connect to a station with acceptable radio channels and which is preferred by the network/UE. In another embodiment the UE may connect to the geographically closest base station.

A UE may connect to a certain base station due to a variety of factors. By way of example only, UE 103 may be located such that it can connect to and be controlled by either of base stations 106 or 107. A determination may be made as to which of base stations 106 and 107 is the optimum base station for UE 103 to receive traffic from. In other words a determination may be made as to which cell or cells a UE should camp on. If, for example, base station 106 and/or its associated cells is experiencing heavy traffic and base station 107 and/or its associated cells is experiencing relatively light traffic, then a determination may be made for UE 103 to receive traffic from base station 107 so that the traffic is more evenly spread

between the base stations and/or cells. The action of directing traffic for a user equipment via a particular base station in favour of another base station may be referred to as "traffic steering" i.e. the traffic is steered away from a first base station towards a second base station.

Analysis of certain parameters may assist in a traffic steering operation. In 3G networks the QoS profile of the PDP context (and its associated parameters) may be analysed. In 4G networks the QoS profile of an Evolved Packet System (EPS) bearer (and its parameters) may be analysed.

Table 1 below sets out parameters of a PDP context and EPS bearer which may be analysed:

QoS profile of a PDP context (3G)	QoS profile of a EPS bearer (4G)
• Residual BER • SDU error ratio • Delivery of erroneous SDUs • Maximum SDU size • Delivery order • Transfer delay • Traffic class (UMTS TC) • Traffic handling priority (THP) • Allocation retention priority (ARP) • Maximum bit rate UL/DL • Guaranteed bit rate UL/DL (GBR)	• Label ✓ Bearer type (Guaranteed or non-guaranteed bit rate) ✓ Packet delay ✓ Packet Loss • Guaranteed Bit Rate (UL/DL) • Maximum Bit Rate (UL/DL) • Allocation/Retention Priority

Table 1

It should be appreciated that each of the parameters in Table 1 can be analysed individually. Alternatively a combination of any number of the parameters may be used.

The determination during the traffic steering method may be based not only on cell specific performance indication, but may also be based upon performance information of backhaul and core networks. This information may be derived from inspecting data packets. In some embodiments deep packet inspection (DPI) may be used. In DPI the packets are inspected at an inspection point. In some embodiments the inspection point may be a Serving GPRS Support Node (SGSN). In other embodiments the inspection is carried out at a Gateway GPRS Support Node (GGSN). The inspection can also take place at any other node (e.g. UE or base station). During DPI the data part of one or more packets may be inspected. The header of the one or more packets may also be inspected. In some embodiments inspection may take place at more than one inspection point. For example inspection may take place at the cell level (e.g. at a base station) as well as at the gateway level (e.g. GGSN). Obtaining accurate information from DPI may allow for more dynamic and more efficient traffic steering then maybe provided by "best effort" applications. User information may also be obtained from a home subscriber server (HSS) or home location register (HLR). The user information may be combined with that obtained from DPI to assist with the traffic steering operation.

Gathering the information in this manner may provide an accurate reflection of both the load level of the air interface and the effective transmission quality of a cell or backhaul network in question.

As a further refinement, user traffic quality of service (QoS) information may be used in the traffic steering determination. The QoS information may comprise requirements on aspects of a connection such as service response time, loss, signal-to-noise ratio, cross-talk, echo, interrupts, frequency response, loudness levels etc.In a further refinement still operator QoS policy may be used in the traffic steering decision making. The operator QoS policy may be used independently or in conjunction with the user traffic QoS information in the traffic steering determination. A node may store the operator quality of service policy directly, or retrieve the quality of service policy before the determination is made. The operator quality of service policy may be determined from the corresponding network configuration made based

on the policy. The use of the user traffic QoS information and operator QoS policy may be in addition to the DPI measurements.

The QoS parameters may be obtained in a number of ways. The information may include parameters of a user data session between a UE and a gateway node. In the case of a 3G network the QoS parameters may be extracted from an associated PDP context (packet data protocol context). The PDP context may contain the subscriber's session information for an active session. The PDP context may be stored on one or both of both of the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN).

In the case of a 4G network the QoS profile may be obtained from an associated EPS bearer.

In either of these cases the information may be assigned by the GGSN.

Using this information a decision may be made as to which base station traffic is to be sent to. Once a decision has been made the chosen cell may be termed the "target cell". A cell with a relatively high level of high-QoS traffic may have a low likelihood of being the target cell in comparison with a cell with a relatively low level of high-QoS traffic.

In some embodiments the cells or base stations may be assigned a target QoS distribution. In other words each cell may be assigned a QoS level or threshold. The cell attempts to keep its QoS within this predefined threshold. The threshold could be set by any of a UE, GGSN, SGSN or any other network node. The threshold could even be set by the base station itself.

The level of the QoS distribution threshold may affect the determined target cell in a traffic steering determination operation. For example if a decision is being made between a cell which has a high QoS distribution target and a cell which has a low QoS distribution target then it will most likely be determined to steer the traffic to the

low threshold cell so as not to negatively affect the quality of service in the high threshold cell.

In some embodiments each cell is configured to attempt to reach its target QoS distribution. The actual or measured QoS in a cell may be derived in a manner as described above e.g. from DPI measurements and knowledge of the cell's actual or measured traffic QoS at the gateway node. Accordingly traffic steering towards and away from a cell may be most prevalent when there is a significant difference between the target QoS distribution and the actual measured QoS distribution of the cell. For example if a cell can accommodate more traffic whilst satisfying its QoS target, then traffic will be steered towards that cell. If on the other hand a cell has too much traffic and cannot meet its QoS target then traffic will be steered away from that cell. Traffic may also be steered away from a cell that is at or near its QoS distribution target.

Figure 4 is a flowchart showing steps during a traffic steering operation according to some embodiments.

At step S1 a determination is made that there is a traffic flow that needs to be served by a cell. For example the traffic flow may be between a UE and an external IP server. For example, referring to Figure 1, the traffic flow may be between any of UEs 102, 103 and 105 and communication network 113.

At step S2 a determination of the user traffic QoS is made. That is properties of the traffic flow may be determined. As discussed above this information may be derived from DPI measurements of the traffic flow, for example at one of gateway nodes 111 or 112. At step S2 a determination may also be made of operator QoS policy. As discussed above, the operator QoS policy may be stored in memory or retrieved from another node or database.

At step S3 a determination is made of a suitable cell to which this traffic flow can be steered. As discussed above this determination may include a comparison of the actual quality of service distribution in candidate cells to the target quality of service

distribution of those candidate cells. The determination may also include determining the effect of the traffic flow in question on those candidate cells. For example if it is determined that steering a particular traffic flow to a cell will result in the quality of service in that cell dropping below a predefined threshold, then it may be determined not to steer the traffic to that particular cell. If on the other hand it is determined that the traffic can be steered to a cell whilst keeping that cell within its quality of service threshold, then such a steering operation may be completed.

At step S4 a determination is made as to which cell to direct the traffic on the basis of the estimations or calculations made at step S3.

At step S5 the traffic is steered to the chosen cell.

In a refinement of the method of Figure 4 a further monitoring tool may be used to detect information in addition to that detected during DPI, such as the specific cells of the related user traffic. A composed measurement of the DPI and the above-mentioned further information may be sent to an operation support system (OSS) as counters/reports. Using this information, the traffic steering logic in the OSS may decide if a specific cell should be made easier or harder to be the traffic steering target from its specific neighbour cell. The OSS may then reconfigure the corresponding thresholds for those cell(s) via the base stations or radio network controller (RNC). In some embodiments the OSS stores the operator quality of service policy directly, or retrieves the quality of service policy before the determination is made.

In some embodiments the one or more base stations may act simply as a conduit for the traffic flow. That is the determination of where to steer the traffic may be made at a higher level, such as the OSS, rather than in the base station itself. In other embodiments when not acting simply as a conduit a base station could have the control during traffic steering, for example, based on comparing its monitored actual traffic distribution in the run-time over the base-station provided QoS classes with, for example, OSS-set target traffic distribution over the base-station provided QoS classes. If the difference of traffic on any of the QoS classes exceeds a pre-

configured threshold (set by OSS for example), the base station could decide to enter the traffic steering mode for the said traffic of the said QoS classes. If the difference of traffic on any of the QoS classes is smaller than another pre-configured threshold (set by OSS for example), the base station can decide to end the traffic steering mode for the said traffic of the said QoS classes.

The operation of setting cell thresholds is discussed further with respect to Figure 5. In the example of Figure 5 there are shown 6 cells (A, B, C, D, E and F). Cell A overlaps with each of cells B, C, D, E and F. Cell A may therefore be considered a "source cell". There are five cell pairs as follows:

cell A-cell B
cell A-cell C
cell A- cell D
cell A-cell E
cell A-cell F.

For each cell pair a set of thresholds is defined. These thresholds consist of an "enter steering threshold" and an "end steering threshold". The "enter steering threshold" is the threshold at which a given cell needs to enter a steering mode i.e. threshold at which a cell needs to steer traffic away from itself. This may be due to the cell being at or near capacity and therefore needing to steer traffic away from itself. The "end steering threshold" is the threshold at which a cell does not need to steer traffic away from itself and therefore the steering mode can be ended. This may be due to the cell having capacity for more traffic, and therefore may allow traffic to enter rather than steering it away. The cell configuration of Figure 5 therefore consists of the following steering threshold sets:

$enter\text{-}steering\text{-}threshold_{AB}$ *and* $end\text{-}steering\text{-}threshold_{AB}$
$enter\text{-}steering\text{-}threshold_{AC}$ *and* $end\text{-}steering\text{-}threshold_{AC}$
$enter\text{-}steering\text{-}threshold_{AD}$ *and* $end\text{-}steering\text{-}threshold_{AD}$
$enter\text{-}steering\text{-}threshold_{AE}$ *and* $end\text{-}steering\text{-}threshold_{AE}$
$enter\text{-}steering\text{-}threshold_{AF}$ *and* $end\text{-}steering\text{-}threshold_{AF}$

The above thresholds may affect the traffic steering decision from cell A to one of its neighbouring cells. For example the traffic steering decision from cell A to cell C can be altered by altering the pair of threshold from cell A to cell C (i.e. alter enter steering threshold AC and alter end steering threshold AC). The altered thresholds may make cell A easier or harder to enter the steering mode (i.e. to start the steering) as well as harder or easier to end steering mode (i.e. to end steering) accordingly.

In some embodiments the traffic steering (TS) mode may be embedded inside another TS-mode.

It should of course be appreciated that the cell configuration of Figure 5 is by way of example only and any other number of cells could be provided. For conciseness the cell pairings of cell A (the "source cell") with each of cells B to F has been discussed. It should however also be appreciated that other cell pairings are possible and that each of those cell pairings may have defined end steering and enter steering thresholds. For example other cell pairings are cell B-cell C, cell C-cell D, cell D-cell E, cell E-cell F, and cell F-cell B etc. In the example given above each cell has two thresholds: an enter-steering threshold and an end-steering threshold. Alternatively each cell may have a single threshold. If the determined value is higher than this single threshold then the cell may operate in a traffic steering mode, and if the determined value is lower than this single threshold then the cell may operate in a non traffic-steering mode. Alternatively different cells may operate with a combination of the above mechanisms i.e. one or more cells may operate with both the enter-steering and end-steering thresholds, whilst one or more other cells may operate with a single threshold.

It should be appreciated that the methods described above can be combined in any way. For example the enter steering and end steering threshold setting discussed with respect to Figure 5 can be combined with the steering operation discussed with respect to Figure 4. The threshold setting operation may occur as a step prior to step S1 in Figure 4, or could occur between step S1 and S2, or between steps S2 and S3.

Accordingly some embodiments may provide an improved traffic steering procedure.

An appropriately adapted computer program code product or products may be used for implementing the embodiments, when loaded on an appropriate data processing apparatus, for example for determining geographical boundary based operations and/or other control operations. The program code product for providing the operation may be stored on, provided and embodied by means of an appropriate carrier medium. An appropriate computer program can be embodied on a computer readable record medium. A possibility is to download the program code product via a data network. In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Embodiments of the inventions may thus be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

It is also noted herein that while the above describes exemplifying embodiments of the invention, there are several variations and modifications which may be made to the disclosed solution without departing from the scope of the present invention.

Claims

1. A method comprising:

determining if a cell can accommodate a traffic flow, said determining based upon a target quality of service for users of said cell and a measured quality of service for users of said cell; and

steering said traffic flow to or away from said cell in dependence on said determination.

2. A method comprising:

determining, at a node, if a cell at least partially controlled by said node can accommodate a traffic flow, said determining based upon a target quality of service for users of said cell and a measured quality of service for users of said cell; and

steering said traffic flow to or away from said cell in dependence on said determination.

3. A method as set forth in claim 1 or claim 2, wherein said determining comprises comparing said target quality of service to said measured quality of service.

4. A method as set forth in any preceding claim, wherein said measured quality of service is at least partially determined from parameters of a traffic flow.

5. A method as set forth in claim 4, wherein said parameters are comprised in a Packet Data Protocol context.

6. A method as set forth in claim 4, wherein said parameters are comprised in an Evolved Packet System bearer.

7. A method as set forth in any of claims 4 to 6, wherein said parameters are obtained by deep packet inspection of said traffic flow.

8. A method as set forth in any preceding claim, wherein said target quality of service is obtained from operator quality of service policy.

9. A method as set forth in any preceding claim wherein said operator quality of service policy is one of: stored in memory; retrieved from a node.

10. A method as set forth in any preceding claim, wherein said determining comprises obtaining user information from a home subscriber server or home location register.

11. A method as set forth in any preceding claim, wherein if it is determined that said cell can accommodate said traffic flow said traffic flow is steered to said cell.

12. A method as set forth in any preceding claim, wherein if it is determined that said cell cannot accommodate said traffic flow, then said traffic flow is steered away from said cell.

13. A method as set forth in claim 1 or any other claim when dependent upon claim 1, wherein said determining is carried out in an operation support system node.

14. A method as set forth in claim 2 or any other claim when dependent upon claim 2, wherein said node is configured to send an update message to a further node confirming that said traffic flow has been steered to or away from said cell.

15. A method as set forth in claim 2 or any other claim when dependent upon claim 2, wherein said node comprises a base station.

16. A method comprising:

configuring a cell to operate in one of a traffic-steering mode and a non traffic-steering mode; and

using quality of service information associated with said configured mode for use in said configured mode.

17. A method as set forth in claim 16, wherein said cell is configured to operate in said non traffic-steering mode when a measured quality of service for users in said cell meets a first pre-determined quality of service level.

18. A method as set forth in claim 16 or 17, wherein said cell is configured to operate in said traffic-steering mode when a measured quality of service for users in said cell meets a second pre-determined quality of service level.

19. A method as set forth in claim 17, wherein said first pre-determined quality of service level may be altered.

20. A method as set forth in claim 18, wherein said second pre-determined quality of service level may be altered.

21. A method as set forth in any of claims 16 to 20, wherein when said cell is in said traffic-steering mode, said traffic is steered to a second cell.

22. A method as set forth in any of claims 16 to 21, wherein said configuring is carried out by an operation support system node.

23. A computer program comprising computer executable instructions which when run on one or more processors perform the method of any of claims 1 to 22.

24. An apparatus;
wherein said apparatus is configured to determine if a cell can accommodate a traffic flow based upon a target quality of service for users of said cell and a measured quality of service for users of said cell;
and wherein said apparatus is configured to steer said traffic flow to or away from said cell in dependence on said determination.

25. An apparatus;
wherein said apparatus is configured to determine if a cell at least partially controlled by said apparatus can accommodate a traffic flow based upon a target quality of

service for users of said cell and a measured quality of service for users of said cell; and

wherein said apparatus is configured to steer said traffic flow to or away from said cell in dependence on said determination.

26. An apparatus;

wherein said apparatus is configured to configure a cell to operate in one of a traffic-steering mode and a non traffic-steering mode; and

wherein said apparatus is configured to use quality of service information associated with said configured mode for use in said configured mode.

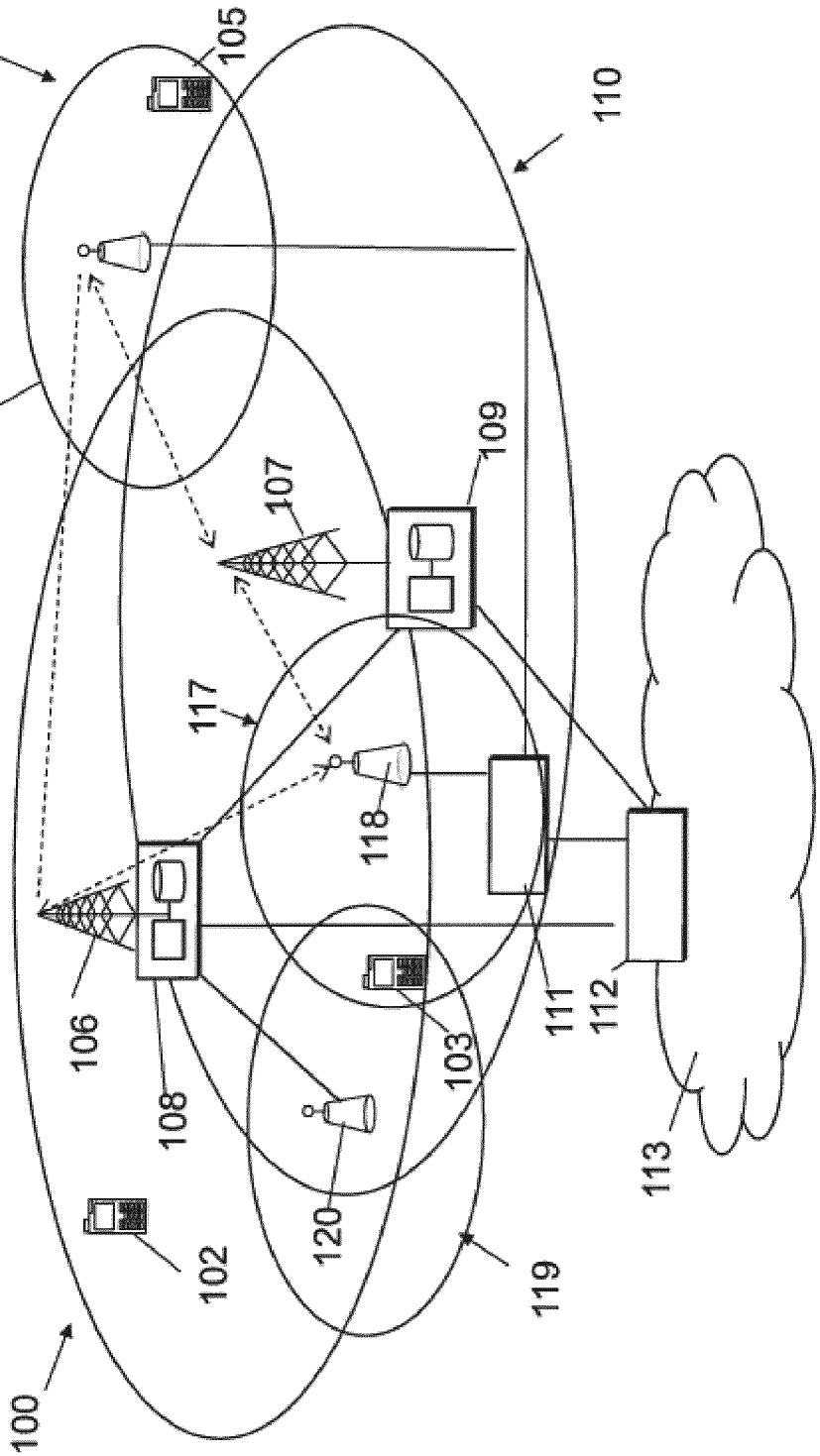
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Figure 1

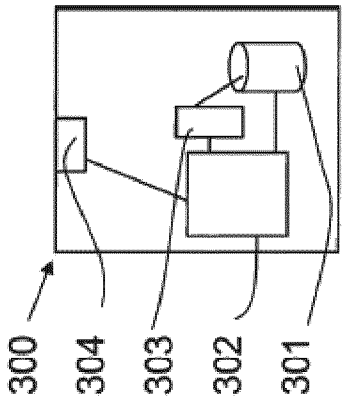

Figure 3

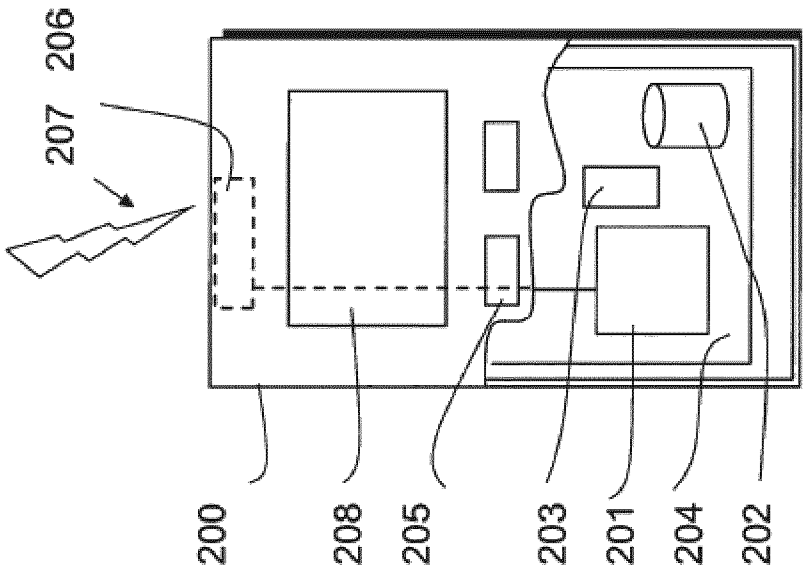

Figure 2

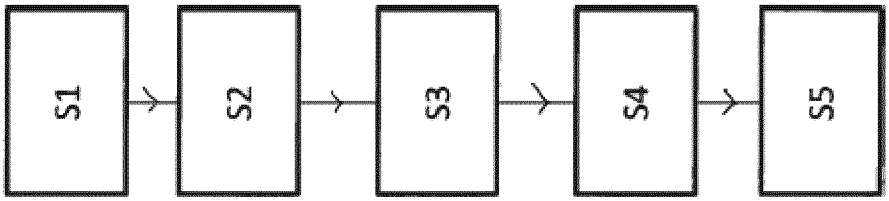

Figure 4

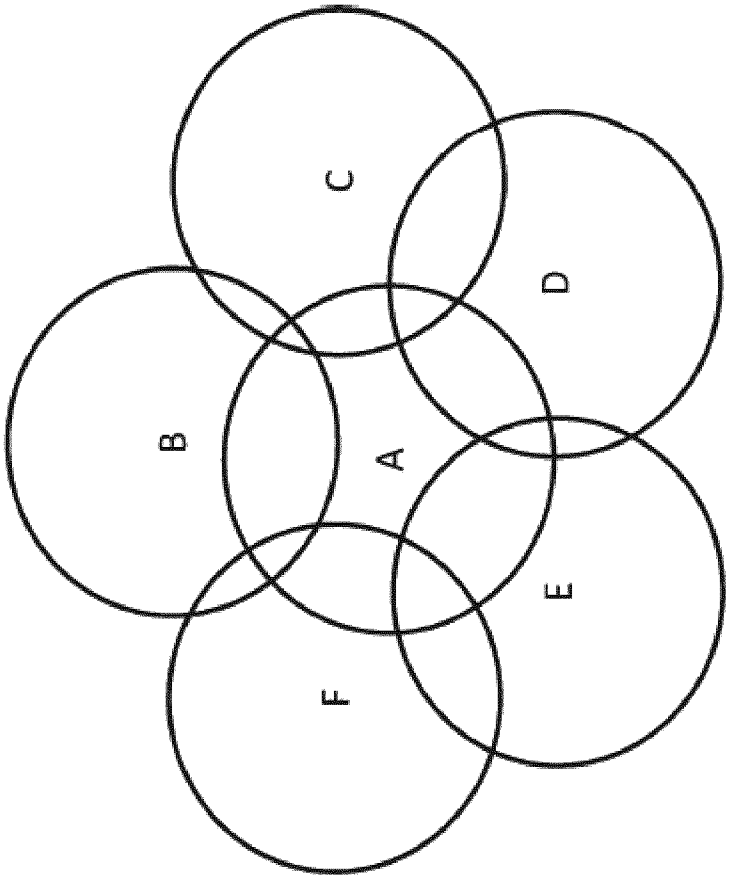

Figure 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/070348

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W28/08 H04W28/24 H04W36/14
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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012/148482 A1 (HIMAYAT NAGEEN [US]; TALWAR SHILPA [US]; ETEMAD KAMRAN [US]; GUPTA VIV) 1 November 2012 (2012-11-01) page 3, line 5 - page 11, line 14 page 12, line 5 - line 20 page 3, line 5 - line 8 page 4, line 21 - page 5, line 8 page 6, line 31 - page 12, line 20 page 13, line 31 - page 14, line 2 page 16, line 15 - line 23 ----- -/--	1-26

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

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 June 2014	03/07/2014

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/070348

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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