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(54) Title: SCALABLE WIRELESS NETWORK ARCHITECTURE BASED ON SUBSCRIBER DISTRIBUTION		
(57) Abstract <p>A wireless communication system constructed according to the present invention assigns mobile units to any of a plurality of mobile switching centers in order to equalize loading. The wireless communication system includes the plurality of mobile switching centers and a base station system which includes a plurality of base station controllers, each of which couples to a plurality of base stations. In one particular construction of the wireless communication system, a dispatching switch couples the base station system to the plurality of mobile switching centers and performs the assignments of the mobile units. In an example of operation, upon attachment of a mobile unit, the dispatching switch determines loading of each of the mobile switching centers. Then, based upon the loading, the dispatching switch assigns the mobile unit to one of the mobile switching centers, the "serving" mobile switching center. During subsequent calls, the dispatching switch establishes a transparent path between a base station controller servicing the call and the serving mobile switching center. Thus, once the serving mobile switching center is determined, operation is transparent to the serving base station controller and the serving mobile switching center. In another particular construction, each of the base station controllers couple to each of the mobile switching centers via a network. In such case, each of the base station controllers and each of the mobile switching centers includes additional equipment which performs at least a portion of the operations of the dispatching switch. The network may be dissimilar to a conventional data structure supported by the wireless communication system.</p>		

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**TITLE: SCALABLE WIRELESS NETWORK ARCHITECTURE BASED ON
SUBSCRIBER DISTRIBUTION**

SPECIFICATION

BACKGROUND

1. Technical Field

5 The present invention relates generally cellular wireless communication systems; and more particularly to a wireless communication system having an architecture that is scalable to compensate for loading levels, able to service any subscriber distribution and compliant with existing standards of operation.

2. Related Art

10 Wireless communication systems are generally known in the art to service wireless communications within a service area. The construction of a wireless communication system typically includes a plurality of base stations dispersed throughout the service area. The base stations couple to base station controllers (BSCs), with each BSC serving a plurality of base stations. Each BSC couples to a mobile switching center (MSC) that also couples to the
15 public switched telephone network (PSTN) and to other MSCs. Mobile units operating within the wireless communication system establish communication with one or more of the base stations. The structure of the wireless communication system is hierarchical such that the load served by the base stations is routed via a predetermined path through a designated BSC to a designated MSC.

20 When the resources of the wireless communication system are insufficient to service load in a particular area, not all call requests will be serviced. Such insufficient capacity causes calls to be dropped, calls to be blocked and produces an overall degradation in system performance. Failing to service customers results in the loss of customers as well as a reduction in the revenue that would otherwise be generated by servicing the calls. Thus, it is
25 extremely important to service as many calls as possible so that subscribers remain with the service provider and so that revenues are maximized.

System capacity may be limited by various components within the system. For example, base stations may become overloaded and fail to service subscribers requesting service. In such cases, as load grows within a particular portion of the system, additional base stations are
30 deployed to handle the additional traffic. Likewise, when a number of base stations connected to any BSC provides overloads the BSC, additional BSCs are deployed to service the

increased load.

MSCs also may become overloaded. The central processing unit and switching capacity of an MSC may only support a maximum level of traffic, messaging and overhead processing. As the capacity of existing MSCs is exhausted, additional MSCs must be introduced into the network. Of course, in the initial deployment of a system, an overall goal is to support the highest number of subscribers with the smallest infrastructure, typically including only a single MSC. This initial deployment not only minimizes the initial cost of deployment but reduces the networking overhead that results from subscriber mobility.

When an MSC (or multiple MSCs) serving a system become overloaded, additional MSCs must be deployed. In deploying additional MSCs within a system, the area served by the system is typically geographically partitioned to equalize loading among the MSCs. As the number of deployed MSCs increases, each served area becomes smaller and the number of boundaries between serving MSCs increases. The additional boundaries cause an increase in subscriber mobility between MSCs, the subscriber mobility consuming additional MSC CPU capacity. Resultantly, as additional MSCs are added within a system, the marginal benefit of each MSC deployment is reduced as the total number of deployed MSCs increases.

Further disadvantages of deploying MSCs relate to the partitioning of the service area. In determining where partitions between MSCs should be placed, an expensive and time consuming study is performed in an effort to equalize loading among MSCs in a manner which minimizes mobility overhead. Then, based upon the study, the system infrastructure must be physically altered and reprogrammed according to the partition. Such operations cause the system to be inoperable for periods of time during which subscribers are not served. Further, due to the difficulty in implementing the partition, system operators generally do not exactly implement the proposed partition which results in unbalanced load and reduced capacity.

Thus, there is a need in the art for a system and associated method which allows additional MSCs to be deployed within a service area such that deployment costs are minimized and mobility servicing is reduced but that provides maximum benefit for the deployment.

SUMMARY OF THE INVENTION

In order to overcome the described shortcomings or prior wireless communication systems, among other shortcomings, a wireless communication system constructed according to

the present invention assigns mobile units to equalize loading among a plurality of mobile switching centers. The wireless communication system includes the plurality of mobile switching centers and a base station system which includes a plurality of base station controllers, each of which couples to a plurality of base stations. To equalize loading among the plurality of base stations, a plurality of mobile units served by the system are assigned to the mobile switching centers so that loading is equalized.

In one particular construction of the wireless communication system, a dispatching switch couples the base station system to the plurality of mobile switching centers and performs the assignments of the mobile units. In an example of operation, upon attachment of a mobile unit, the dispatching switch determines loading of each of the mobile switching centers. Then, based upon the loading, the dispatching switch assigns the mobile unit to one of the mobile switching centers, the "serving" mobile switching center. During subsequent calls, the dispatching switch establishes a transparent path between a base station controller servicing the call and the serving mobile switching center. Thus, once the serving mobile switching center is determined, operation is transparent to the serving base station controller and the serving mobile switching center. Further, because of the nature of its operation, the loading on the dispatching switch is small.

In another particular construction, each of the base station controllers couple to each of the mobile switching centers via a network. In such case, each of the base station controllers and each of the mobile switching centers includes additional equipment which performs at least a portion of the operations of the dispatching switch. The network may be dissimilar to a conventional data structure supported by the wireless communication system. For example, the network may be a packet switched network. In such case data conversions must be performed for the base station controllers and mobile switching centers to operate in conjunction with the network. With such operations supported, a conventional data network may be employed to service the traffic between the base station controllers and the mobile switching centers. In this construction, the dispatching switch may also serve to arbitrate traffic between the base station system and the base station controllers even though it is not in the routing path.

In the operation of such a network-based construction, the base station controllers and mobile switching centers perform operations to initially assign mobile units to the mobile switching centers to balance load. Alternatively, a dispatching switch may be connected to

the network, with the dispatching switch performing the load balancing operations. In either case, when traffic is serviced, the traffic passes across the network between a serving mobile switching center and a serving base station controller.

By equalizing load among the plurality of mobile switching centers, operation according to the present invention increases system capacity. With each of the mobile switching centers serving the whole service area, subscriber mobility overhead is substantially reduced. Thus, the deployment of an additional mobile switching center provides substantial benefit. Further, because the system need not be partitioned, substantial effort is eliminated.

Moreover, other aspects of the present invention will become apparent with further reference to the drawings and specification which follow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a system diagram illustrating a wireless communication system constructed according to the present invention;

FIG. 2 is a system diagram illustrating in more detail the wireless communication system of FIG. 1;

FIG. 3 is a system diagram illustrating an alternate structure of a wireless communication system constructed according to the present invention;

FIG. 4 is a block diagram illustrating a dispatching switch constructed according to the present invention and consistent with the system of FIG. 1;

FIG. 5A is a block diagram illustrating a base station controller (BSC) constructed according to the present invention and consistent with the system of FIG. 3;

FIG. 5B is a block diagram illustrating a mobile switching center (MSC) constructed according to the present invention and consistent with the system of FIG. 3;

FIG. 6 is a logic diagram illustrating operation of a dispatching switch in assigning a mobile unit to one of a plurality of MSCs;

FIG. 7 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in assigning a mobile unit to one of a plurality of MSCs;

FIG. 8 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in detaching a mobile unit from a serving MSC;

FIG. 9 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in setting up a mobile unit originated call;

5 FIG. 10 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in setting up a mobile terminated call;

FIG. 11 is a logic diagram illustrating operation of a wireless communication system constructed according to the present invention in allocating mobile units to a plurality of MSCs serving the wireless communication system;

10 FIG. 12 is a logic diagram illustrating operation of a wireless communication system constructed according to the present invention in reallocating mobile units to a plurality of MSCs serving the wireless communication system;

FIG. 13 is a system diagram illustrating a wireless communication system constructed according to the present invention and an adjacent wireless communication system;

15 FIG. 14 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in handing over a mobile unit between BSCs served by the system; and

FIG. 15 is a system diagram illustrating an alternate system construction according to the present invention with separate traffic and signaling connections.

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DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 is a system diagram illustrating a wireless communication system 100 constructed according to the present invention. The system 100 includes a dispatching switch 102 that couples a plurality of mobile switching centers (MSCs) 104, 106 and 108 to a
25 plurality of base station controllers (BSCs) 110, 112, 114 and 116. Each of the plurality of BSCs 110, 112, 114 and 116 couples to a respective plurality of base stations. As is shown, BSC 110 couples to base stations 120 and 122, BSC 112 couples to base stations 124 and 126, BSC 114 couples to base stations 128 and 130 and BSC 116 couples to base stations 132 and 134. Base stations 120-134 support wireless links between the system and a plurality of
30 mobile units 136, 138 and 140 operating within a respective service area. The system 100 also includes a Home Location Register (HLR) 109 coupled to the MSCs 104, 106 and 108.

Construction and operation of the various components of the wireless communication

system 100 are generally known. Thus, structures and operations described herein are provided only to explain the principles of the present invention and provide little reference to prior, known operations and constructions. In a particular implementation of the wireless communication system 100, the components operate in compliance with the Global system for Mobile communications (GSM). The various operations and constructions described herein compliment operation under GSM standards and provide backwards compatibility with GSM standards, sometimes with minor modifications.

As illustrated, the wireless communication system 100 is constructed similarly to prior systems except for the insertion of the dispatching switch 102 between the MSCs 104, 106 and 108 and the BSCs 110-116 and base stations 120-134 (hereinafter, the combination of the BSCs 110-116 and base stations 120-134 will be referred to as the base station system or "BSS"). The dispatching switch 102 routes communications between the BSS and the MSCs 104, 106 and 108. Each of the MSCs 104-108 couples to the Public Switched Telephone Network (PSTN) 118 to route calls between the PSTN 118 and the mobile units.

Each MSC is capable of servicing a maximum number of calls and a limited level of overhead operation. Thus, according to the present invention, the dispatching switch 102 assigns each mobile unit (e.g., 136, 138 and 140) to an MSC so as to equalize loading among the MSCs. The MSC selected to service the mobile unit is referred to as the serving MSC. Assignment to a particular MSC is typically performed when the mobile unit attaches to the system 100. Upon assignment, the Visitor Location Register (VLR) of the serving MSC is updated to reflect the assignment and an addressing table in the dispatching switch 102 is also updated to reflect the assignment. Further, the HLR 109 is updated to indicate the serving MSC so that calls directed to the mobile unit are correctly routed to the serving MSC.

For example, when mobile unit 136 first powers up in the service area of the system 100, it listens for the beacon signal of a base station and, in response, transmits an attach request to the base station. Alternately, if the mobile unit 136 is already operational when it enters the service area of the system 100, it listens for the beacon signal and, in response, transmits a location update request. The attach request (or location update request) flows through the BSS to the dispatching switch 102 which, upon receipt of the request, determines whether the mobile unit 136 has been assigned to one of the MSCs 104, 106 or 108. If the mobile unit 136 has not been assigned to an MSC, the dispatching switch 102 assigns the mobile unit 136 to one of the MSCs 104, 106 or 108. In determining the MSC assignment,

the dispatching switch 102 considers loading of each of the MSCs 104, 106 and 108 and other system considerations that would make assignment to one of the MSCs over other of the MSCs preferable. In making this determination, the dispatching switch 102 determines that MSC 106 will be assigned to the mobile unit 136 and updates the VLR of MSC 106 and its own addressing table. The MSC 106 or the dispatching switch, depending upon the implementation, then updates the HLR 109 to indicate that MSC 106 is the serving MSC for the mobile unit 136. Subsequently, MSC 106 services all calls from and to the mobile unit 136 via the dispatching switch 102. Calls directed to the mobile unit 136 and serviced by the MSC 106 are either routed to the serving MSC 106 via the PSTN 118 or via a gateway MSC, depending upon the particular implementation.

FIG. 2 is a system diagram illustrating in more detail the wireless communication system 100 of FIG. 1. As shown, the BSS 210 couples to the dispatching switch 102 which also couples to MSCs 104, 106 and 108. Further, each MSC 104-108 couples to the PSTN 118 and also couples to a Home Location Register (HLR) 212 serving the system 100. As shown, the dispatching switch 102 includes an addressing table 202 and each MSC includes a VLR. As shown, MSCs 104, 106 and 108 include VLRs 204, 206 and 208, respectively.

The connections illustrated between the system components are for illustrative purposes only. Actual connections between components may be implemented using various techniques. For example, the connections between MSCs 104, 106 and 108 and the HLR 212 may be implemented using a network that provides signaling and control functions. The connections between the dispatching switch 102 and the MSCs 104-108 may be implemented using a multi-function network that performs both traffic and signaling functions. Alternatively, a first network coupled between the dispatching switch 102 and the MSCs 104-108 provides signaling functions while a second network carries the traffic between the dispatching switch 102 and the MSCs 104-108. The connections between the BSS 210 and the dispatching switch 102 include both signaling and traffic components as well and could also be implemented in a signal network or could be implemented in separate traffic and signaling networks.

The functions performed by the dispatching switch 102 are altered depending upon the construction of the system within which the dispatching switch 102 is implemented. When separate traffic and signaling networks are employed, the dispatching switch may perform only signaling and control functions and simply direct the routing of traffic within the traffic

network. Such a construction will be discussed with reference to FIG. 15. In a system wherein traffic and signaling are supported by a single network, the dispatching switch 102 may be required to perform both traffic routing and signaling functions. Such a dispatching switch will be discussed with reference to FIG. 4.

5 The addressing table 202 contained in the dispatching switch 102 cross-references each mobile unit that has attached to the system to one of the MSCs 104, 106 and 108 of the system. When a mobile unit first attaches to the system, the dispatching switch 102 assigns the mobile unit to one of the MSCs 104, 106 and 108. An entry in the VLR of the serving MSC is made upon such an attachment as well as an entry in the HLR 212 indicating that the
10 serving MSC. Further, upon the assignment of a mobile unit to the serving MSC, an entry is made in the addressing table 202 which cross-references the mobile unit to the serving MSC. When a call from or to the mobile unit is serviced, the traffic is routed between the serving MSC and the BSS 210 by the dispatching switch 102.

 In an example of operation of the system, a mobile unit first attaches to one of the
15 base stations of the BSS 210 or, alternatively, sends a location update request to the BSS 210. The dispatching switch 102 receives the attach request (or location update request) from the mobile unit and, based upon information regarding the MSCs 104-108, assigns the mobile unit to MSC 108, the serving MSC. MSC 108 then accesses the HLR 212 which causes the HLR 212 to be updated and subsequently updates its VLR 208 with the accessed information.
20 When the dispatching switch 102 makes the assignment, the dispatching switch 102 updates the addressing table 202 with the identity of the mobile unit and the identity of the serving MSC 108 to which the mobile unit was assigned.

 During subsequent operations, when a call is initiated from or to the mobile unit, the dispatching switch 102 routes the call between the serving MSC 108 and the BSS 210. By
25 assigning mobile units based upon loading levels of the MSCs, the dispatching switch 102 may equalize loading among the MSCs. Further, because the dispatching switch 102 routes all calls within the system, all, or substantially all handover between MSCs is eliminated. The loading on MSCs due to subscriber mobility is substantially reduced, thus allowing each MSC to service a greater level of traffic.

30 FIG. 3 is a system diagram illustrating an alternate structure of a wireless communication system 300 constructed according to the present invention. As compared to the structure of the system of FIGs. 1 and 2, the system 300 may not include a dispatching

switch. However, in the system 300, MSCs 302, 304 and 306 and BSCs 308, 310, 312 and 314, together, provide functions similar to those provided by the dispatching switch 102. When an optional dispatching switch 320 is included, the dispatching switch operates to assign load to the MSCs.

5 As shown, BSCs 308, 310, 312 and 314 and MSCs 302, 304 and 308 are coupled via a network 316. In FIG. 3, the network 316 is shown to have a ring structure that may operate according to Asynchronous Transfer Mode (ATM) standards. However, the network 316 could operate according to different standards and/or could have a different physical structure. The function of the network 316 is to route traffic/messages between the BSCs 308, 310, 312
10 and 314 and the MSCs 302, 304 and 308. In one particular construction, the network 316 carries only traffic with messages and other control functions carried by a separate network. However, in another particular construction, the network 316 carries traffic as well as supports messaging/control functions. In either case, the connections between the MSCs 302, 304 and 308 and the BSCs 308, 310, 312 and 314 are not hierarchical.

15 Each of the BSCs 308-314 couples to and services a plurality of base stations. Further, each of the MSCs 302, 304 and 306 couples to the PSTN 318. In the operation of the system 300, each mobile unit that is serviced by the system 300 is assigned to one of the MSCs 302, 304 or 306. After such assignment, the serving MSC services all calls originated from or terminated to the mobile unit. In setting up and servicing the call, all required
20 communications and control messages are routed between the serving BSC and the serving MSC via the network 316. As will be described with reference to FIGs. 5A and 5B, the BSCs 308-314 and MSCs 302-306 include components employed to properly route the traffic and messages. These components of the BSCs 308-314 and the MSCs 302-306 operate to assign each mobile unit that is serviced by the system 300 to one of the MSCs 302-306 in a manner
25 that equalizes loading on the MSCs 302-306.

 The system 300 may also include a dispatching switch 320 that performs the overhead required to setup and route traffic/messages between the BSCs 308-314 and the MSCs 302-306. When provided, the dispatching switch 320 includes an addressing table which assigns and maintains routing information used in setting up and routing the traffic/messages. In a
30 fashion similar to that described with reference to the dispatching switch 102 of FIG. 1, when a mobile unit requests service within the system 300, the dispatching switch 320 assigns the mobile unit to one of the MSCs 302-306 based upon loading of the MSCs 302-306. A VLR

of the assigned MSC and the HLR are then updated to indicate that the mobile unit is served by the MSC. Subsequently, the MSC services all traffic/messages for the mobile unit.

FIG. 4 is a block diagram illustrating a dispatching switch 400 constructed according to the present invention consistent with a system having the structure illustrated in FIGs. 1 and 2. The dispatching switch 400 includes a switch fabric 402, a switch processing core 404, an addressing table 406 and a signaling entity. The switch fabric 402 provides physical traffic connections between the BSCs and the MSCs. Each of these traffic connections is represented by a single path. However, in practice, a plurality of calls will be received from and routed to each of the BSCs and each of the MSCs. The switch fabric 402, in some implementations, will service time based switching deconstruction and construction to properly route calls between the BSCs and MSCs. However, in other implementations, the switch fabric 402 performs more complicated switching operations as are required by the system.

The switch processing core 404 performs the overhead operations necessary in assigning mobile units to MSCs and in routing calls and messages between the mobile units and the assigned MSCs. The addressing table 406 is used by the dispatching switch 400 to establish and maintain the assignments. After initial assignment, the dispatching switch 400 accesses the addressing table 406 to determine how to properly route communications and messages between the BSCs and the MSCs. Based upon the access, the switch processing core 404 operates the switch fabric 402 to route traffic.

The signaling entity 408 couples to a signaling network and the switch processing core 404 and performs signaling functions for the dispatching switch 400. During normal operation, the signaling entity 408 interfaces with BSCs and MSCs that are also coupled to the dispatching switch 400 to direct the flow of traffic within the system. Thus, the signaling entity 400 coordinates operation of the dispatching switch 400 with the switch processing core 404 as well as with the coupled components.

FIG. 5A is a block diagram illustrating a BSC 500 constructed according to the present invention that may operate in a system 300 such as that illustrated in FIG. 3. The BSC 500 includes conventional BSC circuitry 502 that interfaces to a plurality of base stations. The conventional BSC circuitry 502 may be substantially similar to that contained within a prior BSC. The BSC 500 also includes data conversion/packaging circuitry 510 that converts traffic and messages between a format supported by the conventional BSC circuitry

502 and a digital packetized format supported by the network 316.

Network routing circuitry 506 couples to the data conversion/packaging circuitry 510 and performs network routing functions. The network routing circuitry 506 includes an addressing table 508 which stores information identifying the serving MSC (as well as the network address) for each mobile unit serviced by the BSC 500. The information stored may include both the identity of the serving MSC and the network address of the serving MSC. The network routing circuitry 506 couples to a network interface 504 which couples the BSC 500 to the network 318.

When the BSC 500 receives traffic/messages from a coupled base station, the conventional BSC circuitry 502 receives the traffic/messages, performs conventional processing operations and passes the traffic/messages to the data conversion/packaging circuitry. The conventional BSC circuitry supports traffic/message data formats that may be inconsistent with the network 318. Thus, the data conversion/packaging circuitry 510 converts the traffic/messages to a digital packet data format when required and passes the traffic/messages to the network routing circuitry.

The network routing circuitry 506 determines the intended destination of the traffic/message based upon its content or based upon instruction received from the conventional BSC circuitry 502. When the intended destination is based upon traffic/message content, the network routing circuitry may access the addressing table 508 to determine the serving MSC of the mobile unit. The network routing circuitry 506 then sets the network address of the traffic/message accordingly and passes the traffic/message to the network interface 504 which passes the traffic/message to the network 318. Based upon the network address appended to the traffic/message, the network 318 routes the traffic/message to the serving MSC.

The network interface 504 receives traffic/messages intended for the BSC 500 from serving MSCs over the network 318. Upon receipt, the network interface 504 passes the traffic/messages to the network routing circuitry 506. If required, the network routing circuitry 506 determines the serving MSC based upon the source network address. The network routing circuitry 506 may also determine the intended BSC based upon content of the traffic/message. In one embodiment, each BSC is assigned a particular network address, with the network routing circuitry having knowledge of its network addresses. After receipt, the network routing circuitry 506 passes the traffic/message to the data conversion/packaging

circuitry 510 which converts the traffic/message to a format consistent with the conventional BSC circuitry 502. The data conversion/packaging circuitry 510 then passes the traffic/message to the conventional BSC circuitry 502. The conventional BSC circuitry 502 then passes the traffic/message to the intended mobile unit.

5 FIG. 5B is a block diagram illustrating an MSC 550 constructed according to the present invention consistent with the system of FIG. 3. The MSC 550 includes conventional MSC circuitry 552 that couples the MSC to the PSTN and to a signaling and control network such a private network. The conventional MSC circuitry 552 includes a VLR 553. The MSC 550 further includes data conversion/packaging circuitry 554 which interfaces with the
10 conventional MSC circuitry 552. Network routing circuitry 556 couples to the data conversion/packaging circuitry 554 and includes a BSC addressing table which, for each mobile unit served by the MSC 550, stores the network location/identity of the BSC that currently serves the mobile unit. Finally, the MSC 550 includes a network interface 560 which interfaces the MSC 550 to the network 316 of FIG. 3.

15 In the operation of the MSC 550, the MSC 550 receives traffic/messages from coupled BSCs over the network 316 via the network interface 560. The network interface 560 passes the traffic/message to the network routing circuitry 556. Based upon information contained in the traffic/messages, the network routing circuitry 556 determines the source of the traffic/message. When BSC identities are not appended to the traffic/message, the
20 network routing circuitry 556 cross references the source network address appended to the traffic/messages to information contained in the BSC addressing table 558 to determine the identity of the BSC that sent the traffic/message to the MSC 550. The traffic/message is then sent to the data conversion/packaging circuitry 554 that converts the traffic/message from their digital packetized format to a format compatible with the conventional MSC circuitry
25 552.

 In transmitting the traffic/message from the MSC 550 to a BSC via the network 316, the data conversion/packaging circuitry 554 receives the traffic/message from the conventional MSC circuitry 552. The data conversion/packaging circuitry 554 then converts the traffic/message to a digital packetized format and passes the converted traffic/message to
30 the network routing circuitry 556. Based upon the identity of the mobile unit for which the traffic/message is intended, the network routing circuitry 556 accesses the BSC addressing table to the network address of the serving BSC. The network routing circuitry 556 then

passes the traffic/message to the network interface 560 which transmits the traffic/message on the network 316. Based upon the appended network address, the traffic/message will be received by the serving BSC.

FIG. 6 is a logic diagram illustrating operation of a dispatching switch in assigning a mobile unit to one of a plurality of MSCs. Operation commences at step 602 wherein the dispatching switch waits for a service request from a mobile unit. The service request may be an attach request when the mobile unit powers-up within the system or a location update request when the mobile unit enters the system. When a service request is received at step 604, operation proceeds to step 606 where the dispatching switch determines whether the mobile unit has been previously assigned to one of the MSCs of the system. This operation could be performed by performing a lookup in the addressing table, searching for a record indexed by the identification of the mobile unit.

If it is determined that the mobile unit has been previously registered with an MSC of the system, the service request is routed to the previously assigned serving MSC at step 608. The MSC may then send a confirmation message to the mobile unit. Then, from step 608, operation proceeds to step 602. Alternately, the dispatching switch could send a confirmation message to the mobile unit based upon the contents of the addressing table.

If at step 606, it is determined that the mobile unit has not been previously assigned to one of the MSCs, operation proceeds to step 610 wherein a serving MSC is selected from the MSCs of the system. As was previously discussed, mobile units are assigned to MSCs to equalize loading among the serving MSCs. Such a determination may be made based upon periodically querying MSCs and determining their loading levels (e.g., every 15 minutes), immediate reference to the addressing table or via an immediate query of the coupled MSCs. A particular operation employed in determining loading based upon query of the MSCs will be described with reference to FIG. 11. Next, at step 612, the selected serving MSC is notified at step 612 of the identity of the mobile unit. In response, the serving MSC performs a location update at step 614, such location update including updating its VLR and the HLR to indicate the serving MSCs identity. Then, at step 616, the dispatching switch updates the addressing table. From step 616, operation returns to step 602.

The operation described with reference to FIG. 6 coincides with the structure of the system of FIGs. 1 and 2 or with the structure of FIG. 3 when a dispatching switch is included in the system 300. However, when the system of FIG. 3 does not include a dispatching

switch, each of the BSCs would, upon receipt of an attach request from a mobile, select a serving MSC according to the technique described. Operations related to assignment to accomplish equalized loading could therefore be employed by each of the BSCs illustrated in FIG. 3 to equalize loading among the MSCs.

5 FIG. 7 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in assigning a mobile unit to one of a plurality of MSCs. At 702 the mobile unit and the BSS establish a signaling link. Once the signaling link is established, the mobile unit sends an attach request to the dispatching switch via the BSS at 704. The attach request could
10 be a RIL-3 MM IMSI Attach <TMSI> message compliant with GSM standards. Upon receipt of the attach request, the dispatching switch selects a serving MSC for the mobile unit and sets up a transparent call to the serving MSC at 706. Then at 708, the dispatching switch passes the attach request to the serving MSC. The serving MSC then sends an attach request to the corresponding VLR of the serving MSC at 710. In sending the attach request to the
15 corresponding VLR, the serving MSC may convert the attach request to another message type, such as a MAP/B Attach IMSI <TMSI> format.

 Upon receipt of the attach request, the VLR creates/updates an entry for the mobile unit, updates the HLR and sends an attach acknowledge to the serving MSC at 712. The attach acknowledge may take the form of an IMAP/B IMSI Attach Acknowledge message.
20 The serving MSC receives the attach acknowledge message and, in response, transmits an attach acknowledge message to the BSS at 714. The attach acknowledge message may take the form of an IMSI Attach acknowledge message. In response, the BSS sends an attach acknowledge message to the mobile unit at 716. Such attach acknowledge message may take the form of an MM IMSI Attach acknowledge message.

25 After the attachment has been acknowledged, the serving MSC sends a clear message to the BSS at step 718. The clear message may take the form of a BSSMAP Clear Command. The BSS releases the signaling link at 720 and the BSS sends a clear complete message to the dispatching switch at 722. The clear complete message may take the form of a BSSMAP Clear Complete. Upon receipt of the clear complete message, the dispatching switch
30 terminates the transparent call with the serving MSC at 724 and sends a clear complete message to the serving MSC at 726. The clear complete message may take the form of a BSSMAP Clear Complete message.

FIG. 8 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in detaching a mobile unit from a serving MSC. At 802 the mobile unit and the BSS establish a signaling link. Once the signaling link is established, the mobile unit sends a detach request to the dispatching switch via the BSS at 804. The detach request could be a RIL-3 MM IMSI Detach <TMSI> message compliant with GSM standards. Upon receipt of the detach request, the dispatching switch looks up the serving MSC for the mobile unit in the addressing table and sets up a transparent call to the serving MSC at 806. Then, at 808, the dispatching switch passes the detach request to the serving MSC. The serving MSC then sends a detach request to the corresponding VLR of the serving MSC at 810. In sending the detach request to the corresponding VLR, the serving MSC may convert the detach request to another message type, such as a MAP/B Detach IMSI <TMSI> format.

Upon receipt of the detach request, the VLR removes an entry for the mobile unit and sends a deregister mobile subscriber message to the HLR at 812. The deregister mobile subscriber message may take the form of a MAP/D Deregister Mobile Subscriber <IMSI> message. The HLR, in response, deregisters the mobile unit and transmits a deregister accepted message to the VLR at 814. The deregister acknowledge message may take the form of a MAP/D Deregister Accepted message. In response, the VLR sends a detach acknowledge message to the serving MSC at 816. The detach acknowledge message may take the form of a IMAP/B IMSI Detach Acknowledge message.

The serving MSC then sends a clear command to the BSS at 818 which may take the form of a BSSMAP Clear Command message. Once the BSS receives the clear command at 818, the BSS releases the signaling link at 820. Then, at 822, the BSS issues a clear complete message to the dispatching switch at 822 which may take the form of a BSSMAP Clear Complete message. At 824, the dispatching switch then terminates the transparent call with the serving MSC. The dispatching switch then sends a clear complete message to the serving MSC which may take the form of a BSSMAP Clear Complete message at 826.

FIG. 9 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in setting up a mobile unit originated call. Upon pressing the SEND button of a mobile unit, the mobile unit transmits a channel request to the BSS on the Random Access Channel (RACH) at 902. The channel request may take the form of a RIL3 - RR - Channel

Request message. In response, the BSS sends a channel grant message at 904, which may be an RIL3 - RR - IMM SABM message on the Access Grant Channel (AGC). With a Stand-alone Dedicated Control Channel (SDCCH) allocated to the mobile unit, the mobile unit sends an identity of message to the BSS on the SDCCH uplink at 906. In response, the BSS
5 sends a message acknowledge (UA) to the mobile unit on the SDCCH downlink at 908. The mobile unit then sends a service request message to the BSS at 910. The service request message may be a Service Request TMSI, Call Setup message on the SDCCH uplink.

The BSS then sends a service request message to the dispatching switch at 912. The service request message may be a Service Request TMSI, Call Setup message. The
10 dispatching switch then sets up a transparent path to the serving MSC at 914, the identity of the serving MSC determined using the identity of the mobile unit via an access of the addressing table. Once this transparent path has been established, traffic and messages flow between the BSS and the serving MSC without interference of the dispatching switch. The dispatching switch next sends a service request to the serving MSC at 916. The service
15 request may be a Service Request TMSI, Call Setup message. The serving MSC then sends a service request to the VLR of the serving MSC at 918. The service request may be a MAP/B Service Request TMSI, Call Setup message. Once these operations are complete, the remainder of the mobile originated call setup sequence is accomplished according to known operations. However, as compared to prior operation, the dispatching switch services the call
20 once it is originated via the transparent call with the serving MSC.

FIG. 10 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention in setting up a mobile terminated call. A mobile locate message is generated by the gateway MSC upon receipt of a call from the PSTN. The gateway MSC sends the mobile
25 locate message to the serving MSC at 1002, the gateway MSC having determined the identity of the serving MSC upon access of the HLR. The mobile locate message may be an IAM <MSRN> message.

The serving MSC then sends a page request to the dispatching switch at 1004 which may be a BSSMAP paging <TMSI, BSC_List, Cell_List> message. The dispatching switch
30 then sends a page request to the BSS at 1006 which may be a BSSMAP paging <TMSI> message. The BSS then pages the mobile unit at 1008. The page may be of the form RIL3 - RR - Page Request <TMSI>. In response to the page, the mobile unit makes a channel

request at 1010 which may be a RIL3 - RR - Channel Request on the RACH. The BSS then sends a channel assignment message to the mobile unit at 1012 which may be an RIL3 - RR - IMM Assigned message on the AGCH. The mobile unit then sends a page response message to the BSS at 1014 which may be a SABM Page response message on the SDCCH Uplink.

5 The BSS then sends a response acknowledge message at 1016 which may be a SABM Page Response Acknowledge message.

The BSS then sends a paging response message to the dispatching switch at 1018. Then, at 1020, based upon the identity of the mobile unit, the dispatching switch accesses its addressing table to determine the identity of the serving MSC. Once the identity of the
10 serving MSC is determined, the dispatching switch sets up a transparent path between the BSS and the serving MSC at 1020. Then, at 1022, the dispatching switch sends a paging response to the serving MSC. Once the path between the BSS and the serving MSC has been established, the system continues with the remainder of the mobile terminated call setup sequence.

15 The operations described with reference to FIGs. 7 through 10 presuppose the existence of a dispatching switch as an intermediary entity between the BSS and the serving MSC. Such a structure was illustrated in FIGs. 1, 2 and 4. However, a differing structure was described with reference to FIGs. 3, 5A and 5B which routed traffic/messages over a network and which optionally included a dispatching switch as a separate element. In such a
20 network based structure, the messages described with reference to FIGs. 7 through 10 may be routed over the network between the BSS and the serving MSC using the network routing methodology described with reference to FIGs. 3, 5A and 5B without requiring a dispatching switch to form a segment of the routing path.

FIG. 11 is a logic diagram illustrating operation of a wireless communication system constructed according to the present invention in allocating a mobile unit to one of a plurality
25 of MSCs serving the wireless communication system based upon immediate query of coupled MSCs. Operation commences at step 1102 wherein the dispatching switch queries the coupled MSCs for loading information. The MSCs respond to the dispatching switch and the dispatching switch receives the capacity responses at step 1104.

30 Based upon the responses which indicate loading levels of the MSCs, the dispatching switch determines a serving MSC for the mobile unit at step 1106. After determining the serving MSC, the dispatching switch directs the serving MSC to update its VLR at step 1108

to indicate that the mobile unit has been assigned to the MSC. The serving MSC, in turn, notifies the HLR to update its entry for the mobile unit to identify the serving MSC. Then, at step 1110, the dispatching switch updates its addressing table to cross-reference the serving MSC to the mobile unit. Based upon the update, in subsequent operations, the dispatching switch will route traffic/messages between the mobile unit and the serving MSC.

In another operation according to the present invention, the MSCs are periodically queried to determine their loading levels. Such an operation would perform steps 1102 and 1104 only. Then, subsequent operation in assigning mobile units to MSCs is based upon the results of the query. Because loading levels typically do not vary drastically over short periods of time, a query interval of 15 minutes may be used in many cases.

FIG. 12 is a logic diagram illustrating operation of a wireless communication system constructed according to the present invention in reallocating mobile units among a plurality of MSCs serving the wireless communication system. Operation commences at step 1202 wherein normal operation continues until a load imbalance among the plurality of MSCs is determined. Since a goal in operating a system constructed according to the present invention is to equally load the plurality of MSCs, when the load becomes imbalanced, as determined at step 1204, rebalancing is performed. The dispatching switch may determine the relative loading of the MSCs based upon a review of the contents of its addressing table.

At step 1206, the dispatching switch queries the plurality of MSCs to determine their excess capacity. The MSCs determine their excess capacity and respond to the dispatching switch at step 1208. Based upon the responses received from the MSCs, the dispatching switch determines the current MSC loading level for each responding MSC and the optimum loading for each of the MSCs at step 1210. Then, at step 1212, based upon the contents of its addressing table, the dispatching switch selects mobile units that are suitable for reassignment to differing base stations. In a typical operation, mobile units currently having calls serviced by the system are considered not suitable for reassignment.

For those mobile units that are selected for reassignment to differing serving MSCs, the VLRs of the MSCs are updated at step 1214 to indicate the new mobile unit assignments. The HLR is then updated to reflect the new serving MSCs for the mobile units that have been reassigned. Then, at step 1216, the addressing table is updated for the reassigned mobile units to indicate the new assignments. After completion of step 1216, operation returns to step 1202. After execution of the steps illustrated in FIG. 12, the MSCs of the system are

substantially equally loaded.

FIG. 13 is a system diagram illustrating a wireless communication system 1300 constructed according to the present invention and an adjacent wireless communication system constructed according to prior techniques. As shown, the system 1300 includes MSCs 1304 and 1306 coupled to a BSS 1318 via a dispatching switch 1308 with both of the MSCs 1304 and 1306 including a VLR. Each of the MSCs 1304 and 1306 is coupled to the PSTN and an HLR 1312. The dispatching switch includes an addressing table 1309. The adjacent system includes an MSC 1302 having a VLR that is coupled to the PSTN 1314 and to a BSS 1316.

When a mobile unit 1320 being served by the adjacent system moves to be within the service area of the system 1300, service by the system 1300 is initiated. Such service is established according to the operation described with reference to FIG. 7. In such operation, the mobile unit 1320 is assigned to MSC 1304 or MSC 1306 based upon loading levels of the MSCs. Then, subsequent traffic/messages are routed by the dispatching switch 1308 according to the assignment. When the mobile unit 1320 moves into the service area of the system 1300 during an ongoing call, handover to the system 1300 is performed according to the operation of FIG. 7 as well as prior handover operations so that the call will continue to be serviced.

When the mobile unit 1320 moves from being served by the system 1300 to the adjacent system, operation occurs according to prior techniques in handover from one system to another system. However, these operations may be altered to coincide with the assignment of the mobile unit 1320 to a serving MSC, either MSC 1304 or MSC 1306 and traffic/messages being routed via the dispatching switch 1308.

FIG. 14 is a message flow diagram illustrating the flow of messages among the components of a wireless communication system constructed according to the present invention during a handover between BSCs served by the system. At 1402, BSS-1 sends a handover message to the serving MSC, requesting handover to BSS-2. Then at 1404, the serving MSC sends the handover request to the dispatching switch, requesting handover to BSS-2. In response, the dispatching switch sets up a transparent path at 1406 between BSS-2 and the serving MSC to service subsequent traffic/messages. Then, at 1408, the dispatching switch passes the handover request to BSS-2 via a portion of the transparent connection.

BSS-2 then responds to the serving MSC with a handover request acknowledgment

message at 1410. With the connections established, the serving MSC sends a handover command to BSS-1 at 1412 and BSS-1 sends the handover command to the mobile unit at 1414. Upon receipt of the handover command, the mobile unit sends a handover access message to BSS-2 at 1416. BSS-2 then sends a handover detected message to the serving
5 MSC at 1418.

When the mobile unit completes its handover operation to BSS-2, the mobile unit sends a handover complete message to BSS-2 at 1420. Then, BSS-2 sends a handover complete message to the serving MSC at 1422. With the handover completed, the serving MSC sends a clear command to BSS-1 at 1424. In response, BSS-1 sends a clear complete
10 message to the dispatching switch at 1426. Then, at 1428, with the handover verified complete, the dispatching switch clears the transparent path between BSS-1 and the serving MSC it had previously established to service traffic/messages between BSS-1 and the serving MSC. After clearing the transparent path between BSS-1 and the serving MSC, the dispatching switch sends a clear complete message to the serving MSC indicating that the
15 path is cleared.

FIG. 15 is a system diagram illustrating an alternate system 1500 construction according to the present invention with separate traffic and signaling connections. As shown, the system includes MSCs 1502, 1504 and 1506, BSCs 1508, 1510 and 1512 and a dispatching switch 1520. Each of the BSCs 1508, 1510 and 1512 is coupled to each MSC
20 1502, 1504 and 1506 by a traffic network connection (as illustrated as solid lines). Further each of the MSCs 1502, 1504 and 1506 and each of the BSCs 1508, 1510 and 1512 are coupled to the dispatching switch 1520 by signaling network connections (as illustrated as dashed lines).

In its operation, the dispatching switch 1520 routes no traffic. However, the
25 dispatching switch sets up and signals the control of all traffic passing between the BSCs 1508, 1510 and 1512 and the MSCs 1502, 1504 and 1506. Thus, the dispatching switch 1520 must operate intimately in control of the traffic network. Techniques generally known may be combined with the teachings described herein to facilitate such operation.

While the invention is susceptible to various modifications and alternative forms,
30 specific embodiments thereof have been shown by way of example in the drawings and detailed description. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but

on the contrary, the invention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the claims.

Claims:

- 1 1. A wireless communication system comprising:
2 a plurality of mobile switching centers;
3 a base station system; and
4 a dispatching switch coupling the base station system to the plurality of switching
5 centers, wherein the dispatching switch assigns mobile units to the plurality of mobile switching
6 centers to equalize load among the plurality of mobile switching centers.
- 1 2. The wireless communication system of claim 1, wherein the base station system
2 comprises:
3 a plurality of base station controllers, each of which couples to the dispatching switch;
4 and
5 for each of the plurality of base stations controllers, a coupled plurality of base stations,
6 each of which supports wireless communications with mobile units.
- 1 3. The wireless communication system of claim 1, wherein the dispatching switch
2 comprises:
3 a switch fabric;
4 a switch processing core; and
5 an addressing table.
- 1 4. The wireless communication system of claim 3, wherein the addressing table
2 cross references each served mobile unit to one of the plurality of mobile switching centers.
- 1 5. The wireless communication system of claim 1, wherein each of the mobile
2 switching centers couples to the public switched telephone network.
- 1 6. The wireless communication system of claim 1 wherein the wireless
2 communication system is substantially compliant with Global System for Mobile
3 Communication standards.

1 7. A wireless communication system comprising:
2 a plurality of mobile switching centers;
3 a base station system having a plurality of base station controllers and a respective
4 plurality of base stations coupled to each of the plurality of base station controllers;
5 a network coupling each of the base stations to each of the plurality of mobile switching
6 centers; and
7 the plurality of base station controllers assigning mobile units to the plurality of mobile
8 switching centers to equalize load among the plurality of mobile switching centers.

1 8. The wireless communication system of claim 7, wherein, upon the attachment of
2 a mobile unit to the wireless communication system, the mobile unit is assigned to one of the
3 plurality of mobile switching centers.

1 9. The wireless communication system of claim 7, wherein the network comprises
2 a data packet network.

1 10. The wireless communication system of claim 9, wherein one of the base station
2 controllers includes:
3 conventional base station controller circuitry coupled to a respective plurality of base
4 stations;
5 data conversion/packaging circuitry;
6 network routing circuitry; and
7 a network interface coupled to the network.

1 11. The wireless communication system of claim 9, wherein one of the plurality of
2 mobile switching centers includes:
3 conventional mobile switching center circuitry that couples the mobile switching center
4 to the public switched telephone network;
5 data conversion/packaging circuitry;
6 network routing circuitry; and
7 a network interface coupled to the network.

1 12. The wireless communication system of claim 7, further comprising a dispatching
2 switch coupled to the network that assigns the mobile units to the plurality of mobile switching
3 centers to equalize load among the plurality of mobile switching centers.

1 13. The wireless communication system of claim 12, wherein the dispatching switch
2 includes a visitor location register routing table.

1 14. In a wireless communication system having a plurality of base station controllers
2 intercoupled to a plurality of mobile switching centers, a method of equalizing load among the
3 plurality of mobile switching centers, the method comprising:
4 receiving an attach request from a mobile unit via a base station controller serving the
5 mobile unit;
6 determining respective loading on the plurality of mobile switching centers;
7 assigning the mobile unit to a serving mobile switching center of the plurality of mobile
8 switching centers in an attempt to equalize loading among the plurality of base station
9 controllers; and
10 subsequently routing traffic between the mobile unit and the serving mobile switching
11 center.

1 15. The method of claim 14, further comprising, upon initiation of a call to the
2 mobile unit, establishing a transparent connection between the serving mobile switching center
3 and a base station controller serving the mobile unit.

1 16. The method of claim 14, further comprising maintaining a addressing table
2 which, for each mobile unit registered, relates a serving mobile switching center.

1 17. The method of claim 14, wherein subsequently routing traffic between the
2 mobile unit and the mobile switching center includes:
3 determining a network address for a serving mobile switching center; and
4 routing the traffic from a serving base station controller to the mobile switching center
5 via a network based upon the network address.

1 18. The method of claim 14, wherein subsequently routing traffic between the
2 mobile unit and the mobile switching center includes:
3 determining a network address for a serving mobile switching center; and
4 routing the traffic from a serving base station controller to the mobile switching center
5 via a network based upon the network address.

1 19. The method of claim 14, wherein subsequently routing traffic between the
2 mobile unit and the mobile switching center includes:
3 determining a network address for a serving base station controller; and
4 routing the traffic from a serving mobile switching center to the base station controller
5 via a network based upon the network address.

1 20. The method of claim 14, further comprising reassigning at least one mobile unit
2 to a different serving mobile switching center of the plurality of mobile switching centers in an
3 attempt to equalize loading among the plurality of base station controllers.

1 21. In a wireless communication system including a plurality of mobile switching
2 centers and a base station system that serves mobile units, a dispatching switch comprising:
3 an interface to the plurality of mobile switching centers;
4 an interface to the base station system; and
5 the dispatching switch coupling the base station system to the plurality of switching
6 centers, wherein the dispatching switch assigns mobile units to the plurality of mobile switching
7 centers to equalize load among the plurality of mobile switching centers.

1 22. The dispatching switch of claim 21, wherein the base station system comprises:
2 a plurality of base station controllers, each of which couples to the dispatching switch;
3 and
4 for each of the plurality of base stations controllers, a coupled plurality of base stations,
5 each of which supports wireless communications with mobile units.

1 23. The dispatching switch of claim 21, further comprising:
2 a switch fabric;
3 a switch processing core; and
4 an addressing table.

1 24. The dispatching switch of claim 21, wherein the addressing table cross
2 references each served mobile unit to one of the plurality of mobile switching centers.

1 25. The dispatching switch of claim 21, wherein each of the mobile switching
2 centers couples to the public switched telephone network.

1 26. The dispatching switch of claim 21, wherein the wireless communication system
2 is substantially compliant with Global System for Mobile Communication standards.

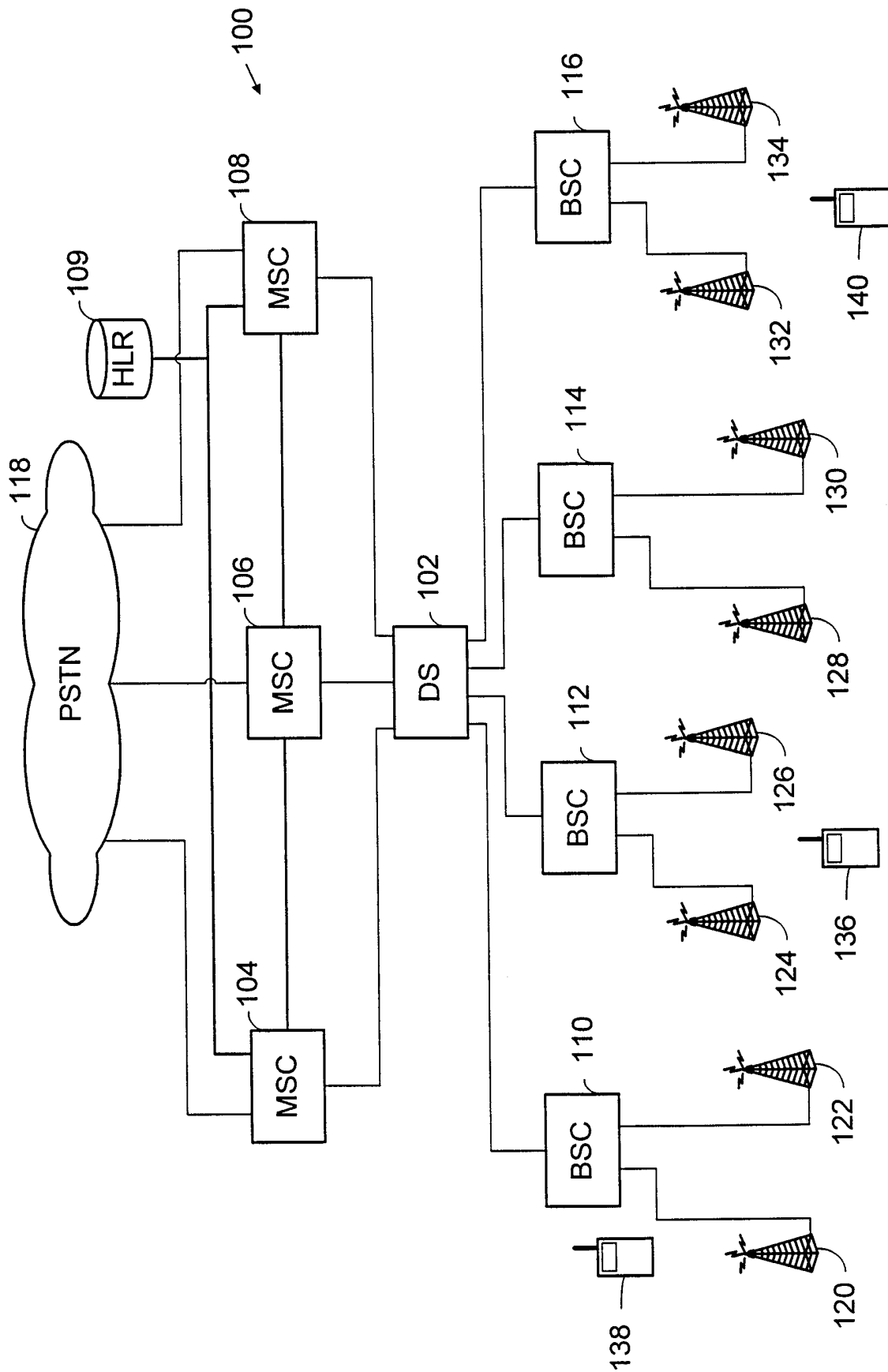


FIG. 1

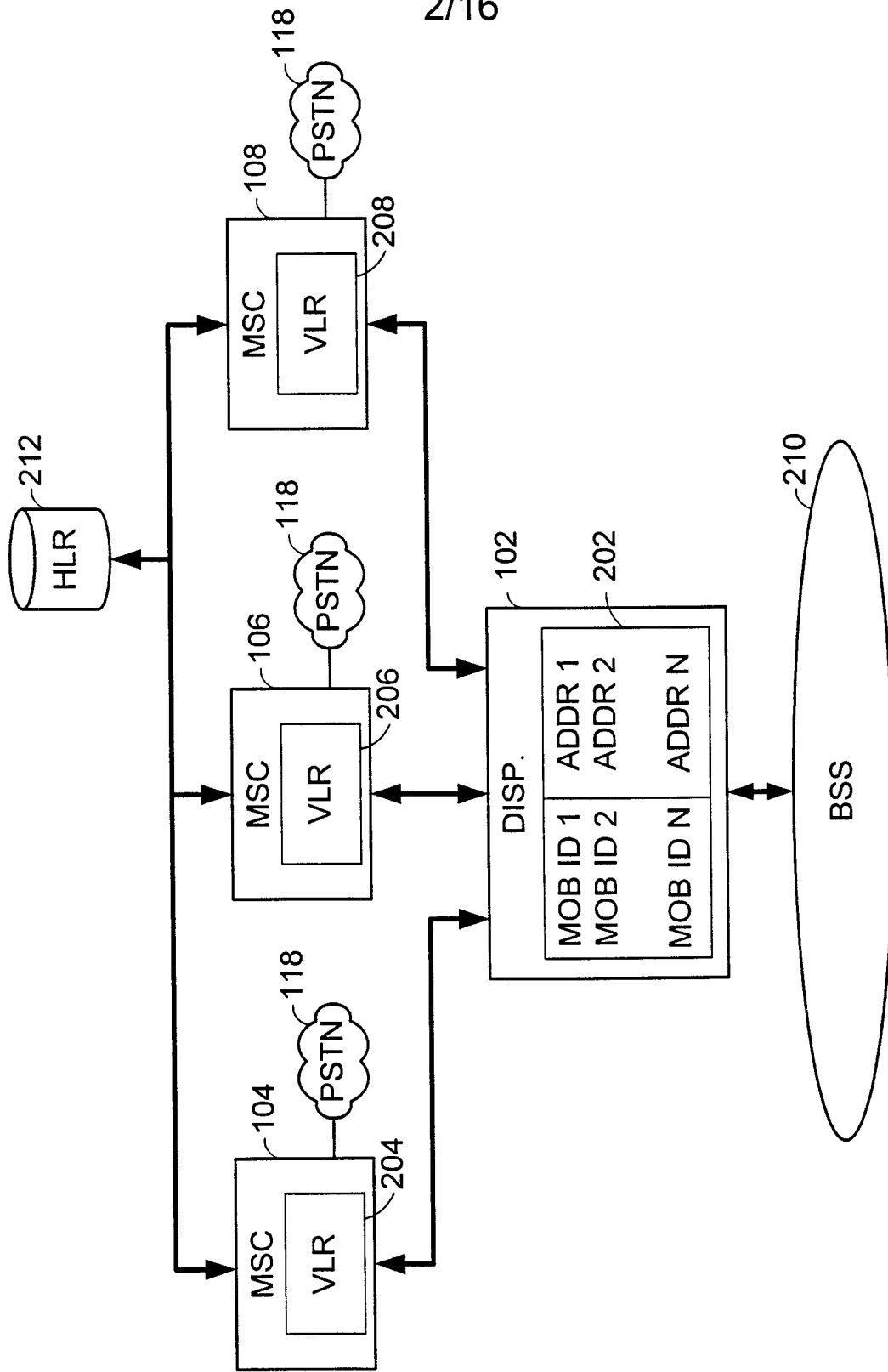


FIG. 2

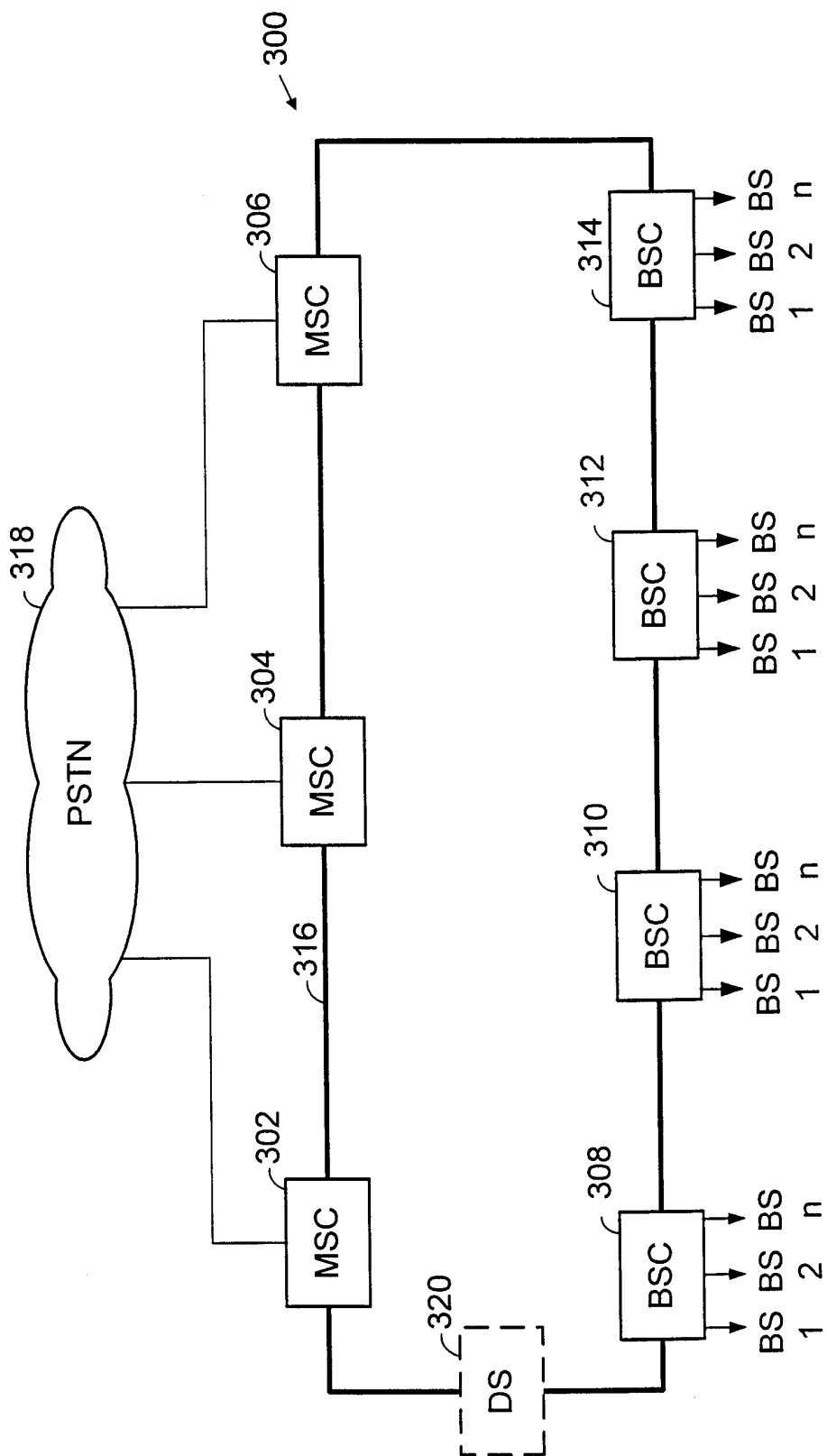


FIG. 3

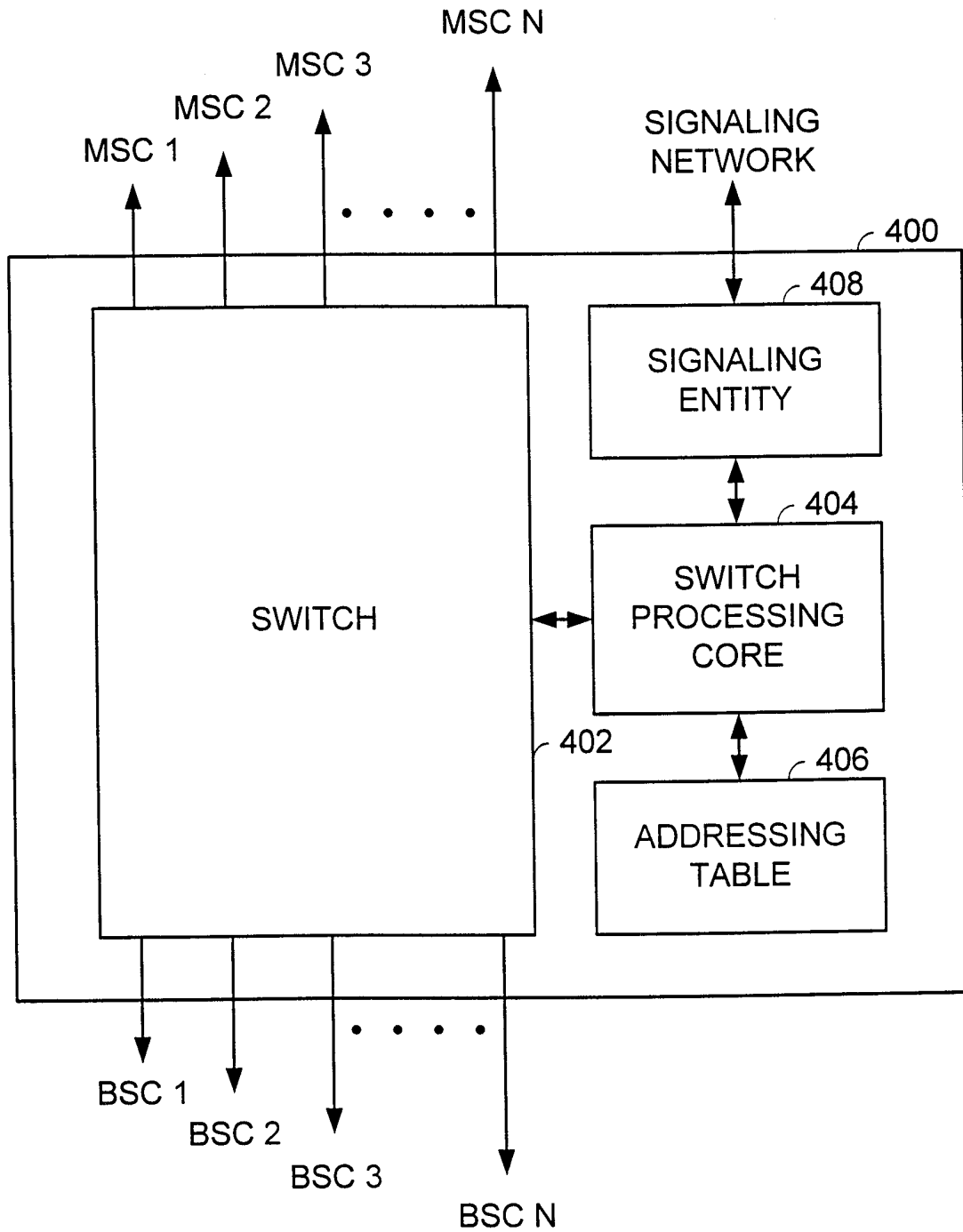


FIG. 4

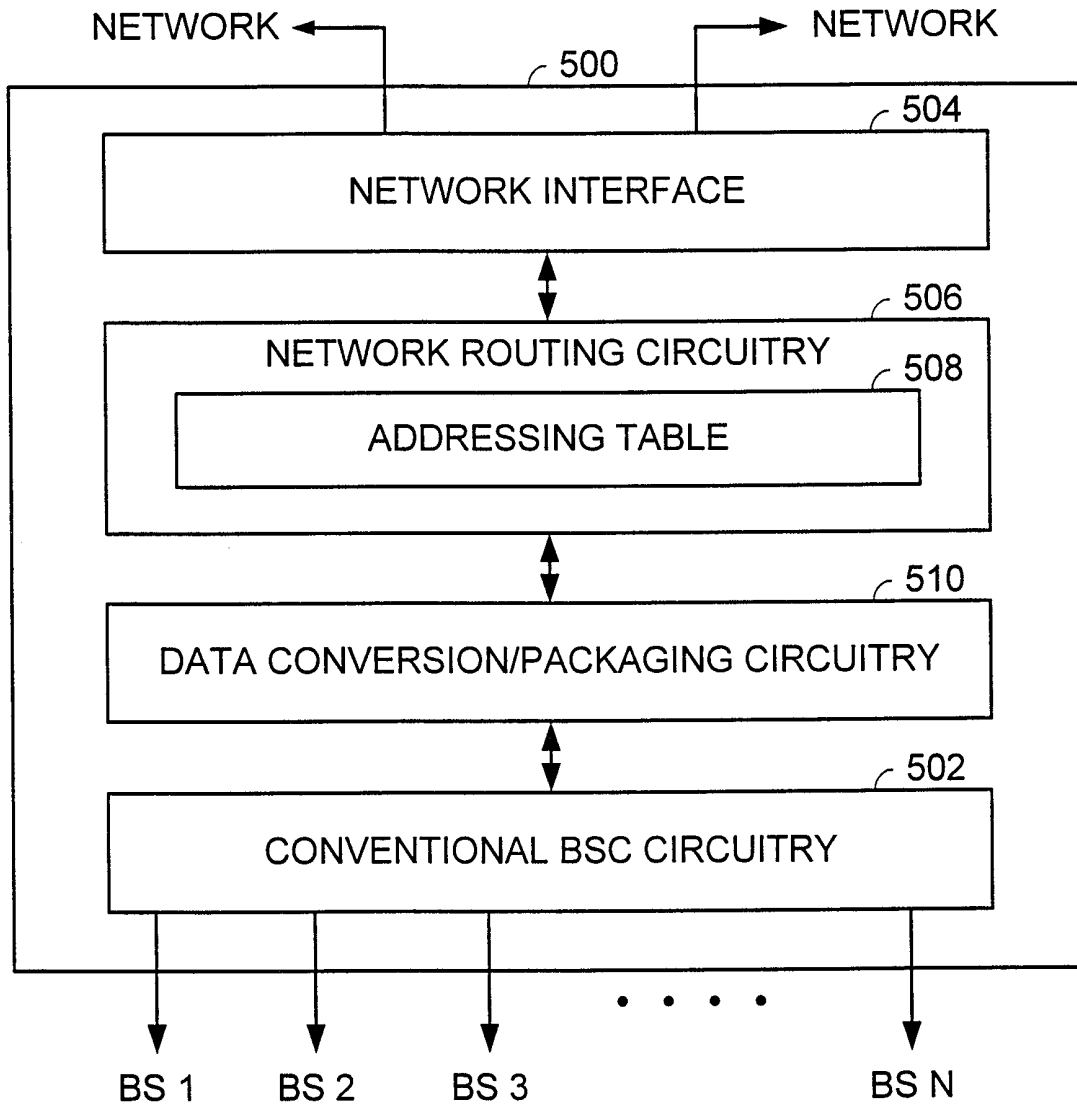


FIG. 5A

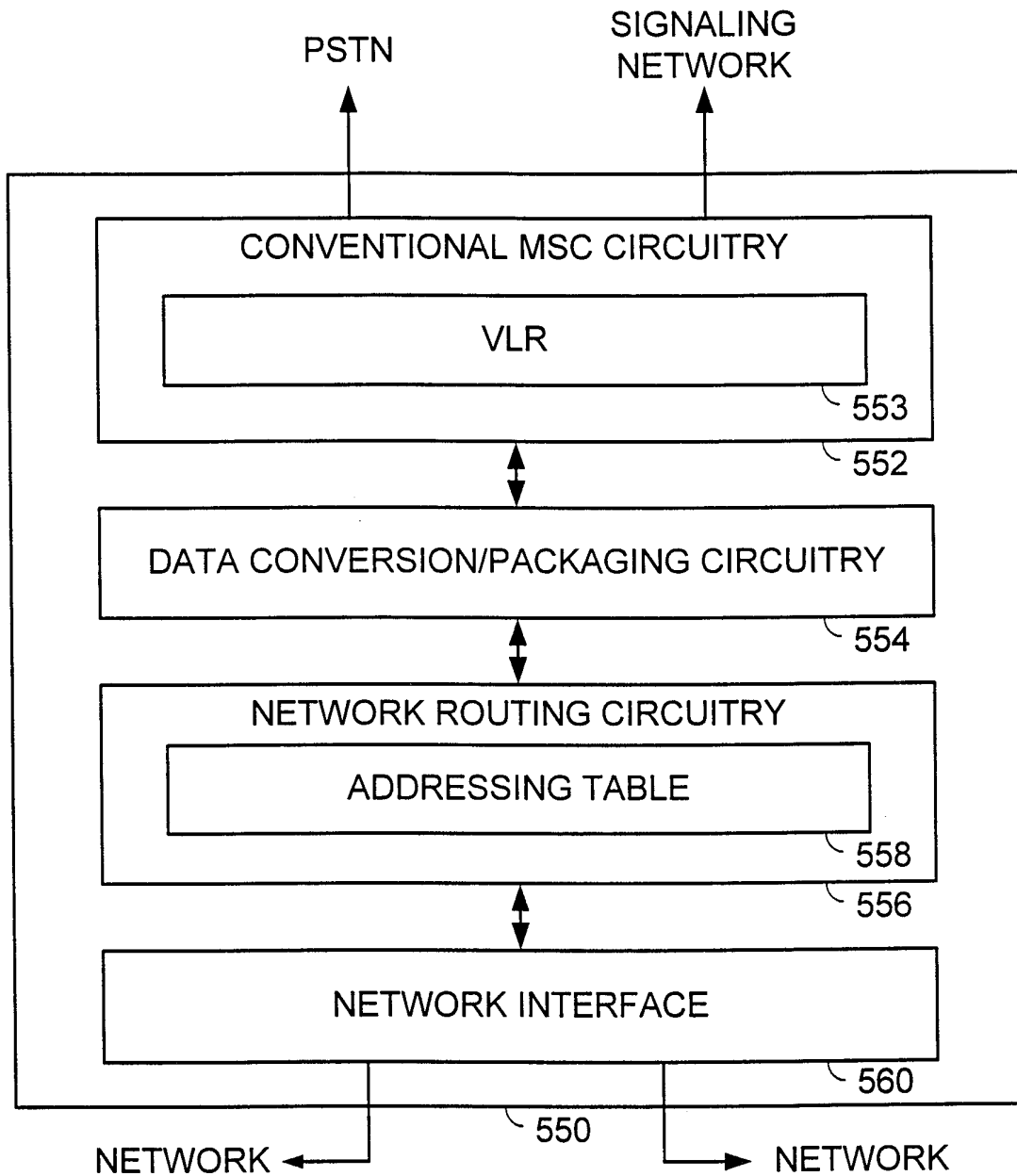


FIG. 5B

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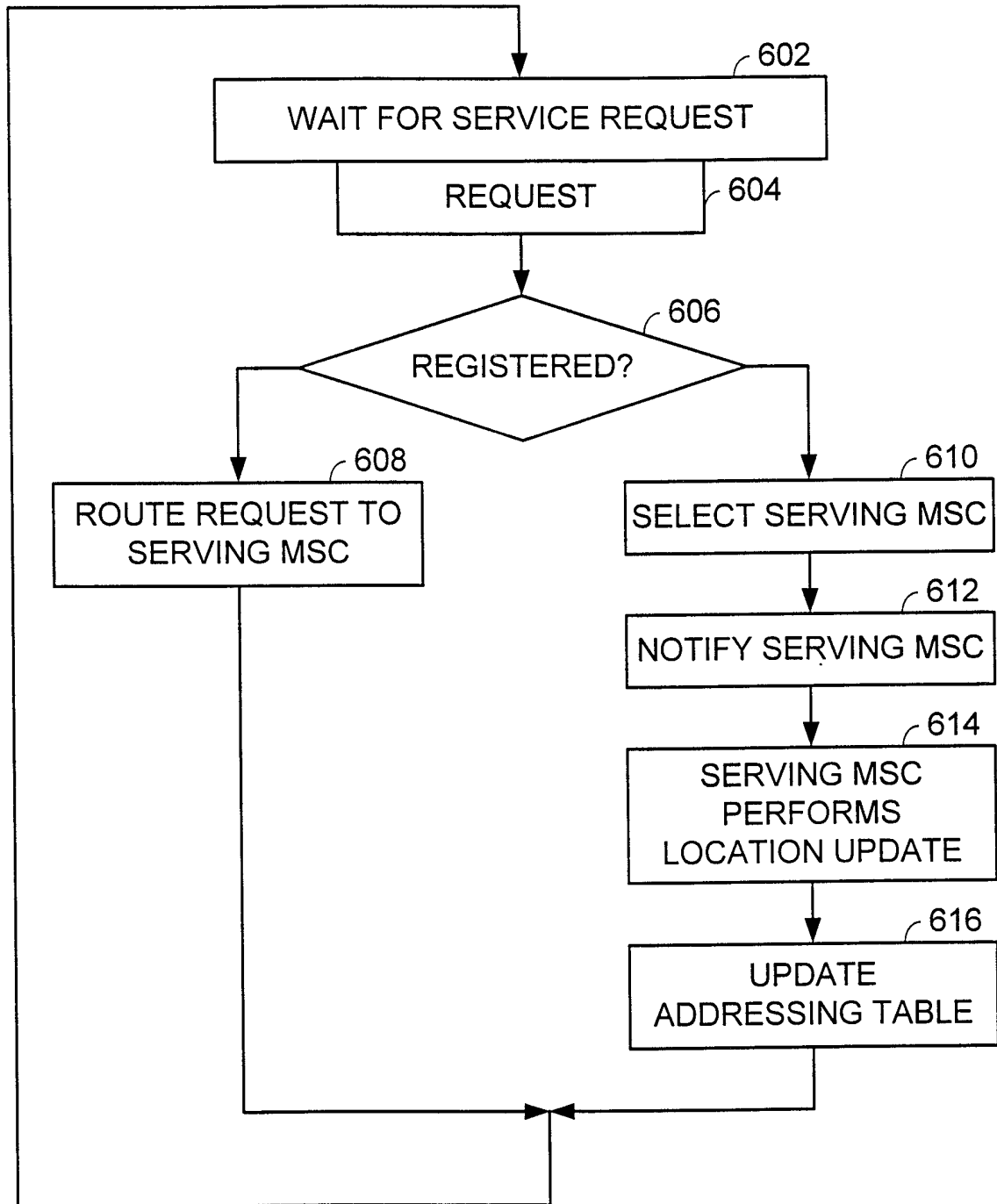


FIG. 6

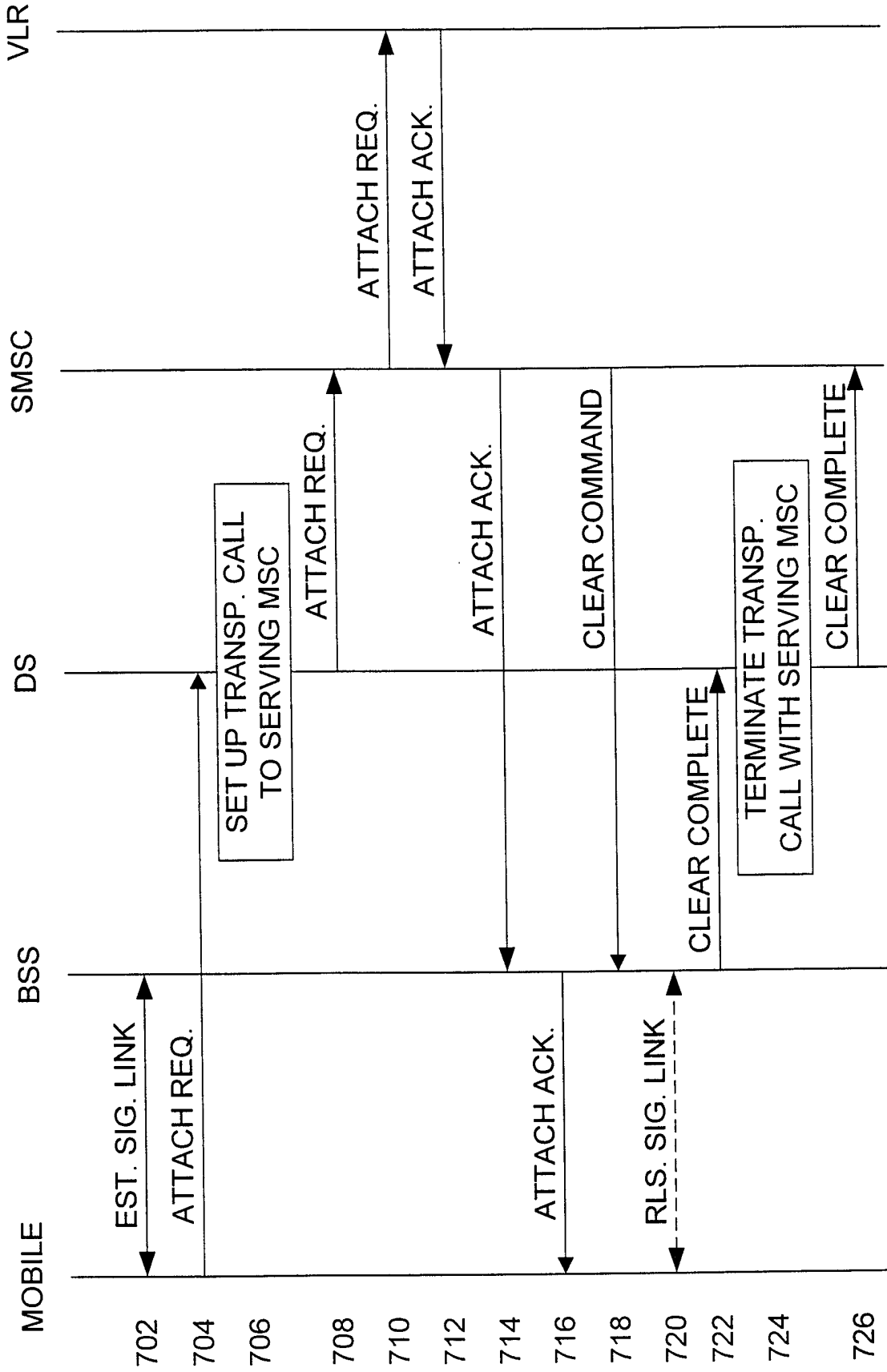


FIG. 7

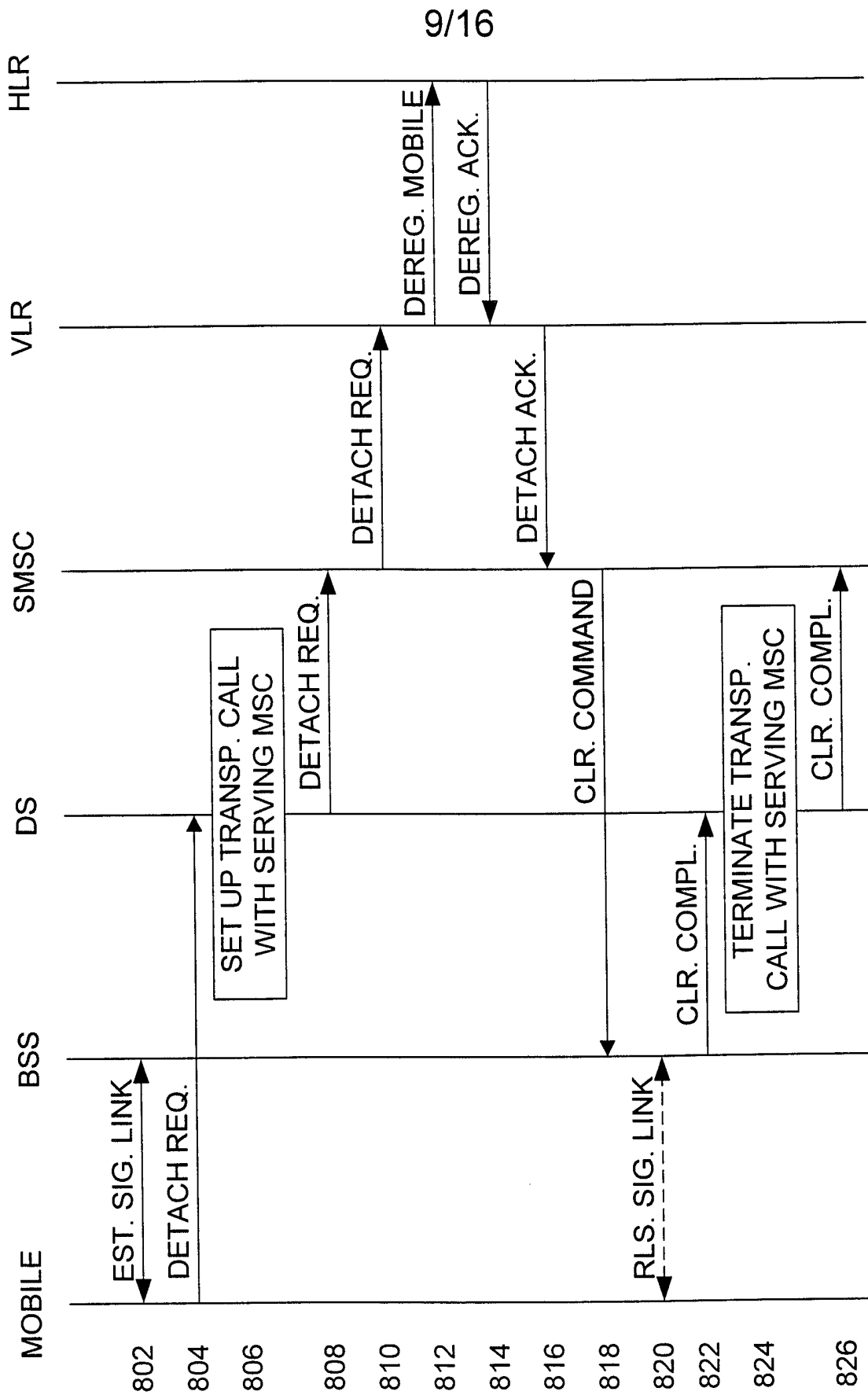


FIG. 8

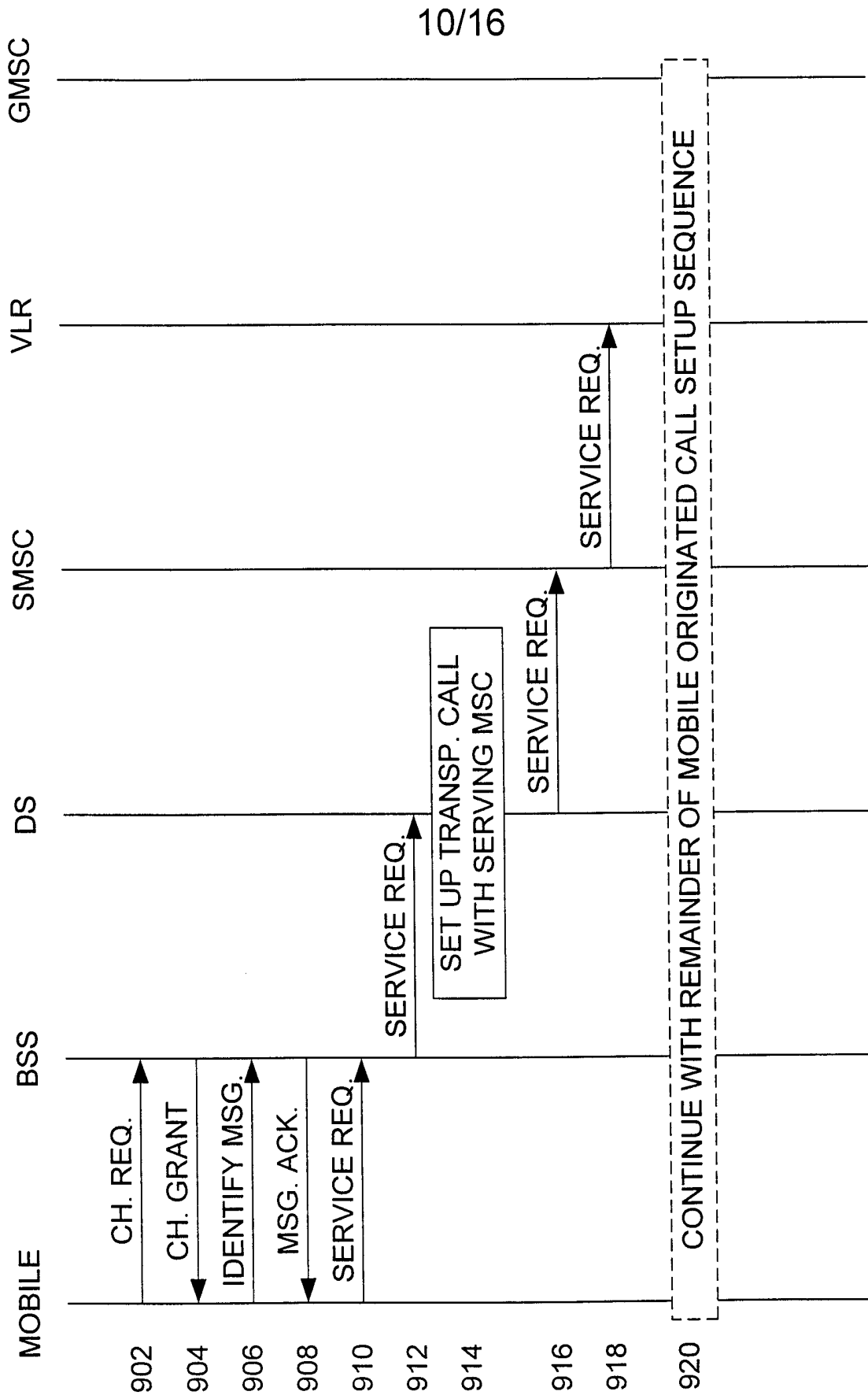


FIG. 9

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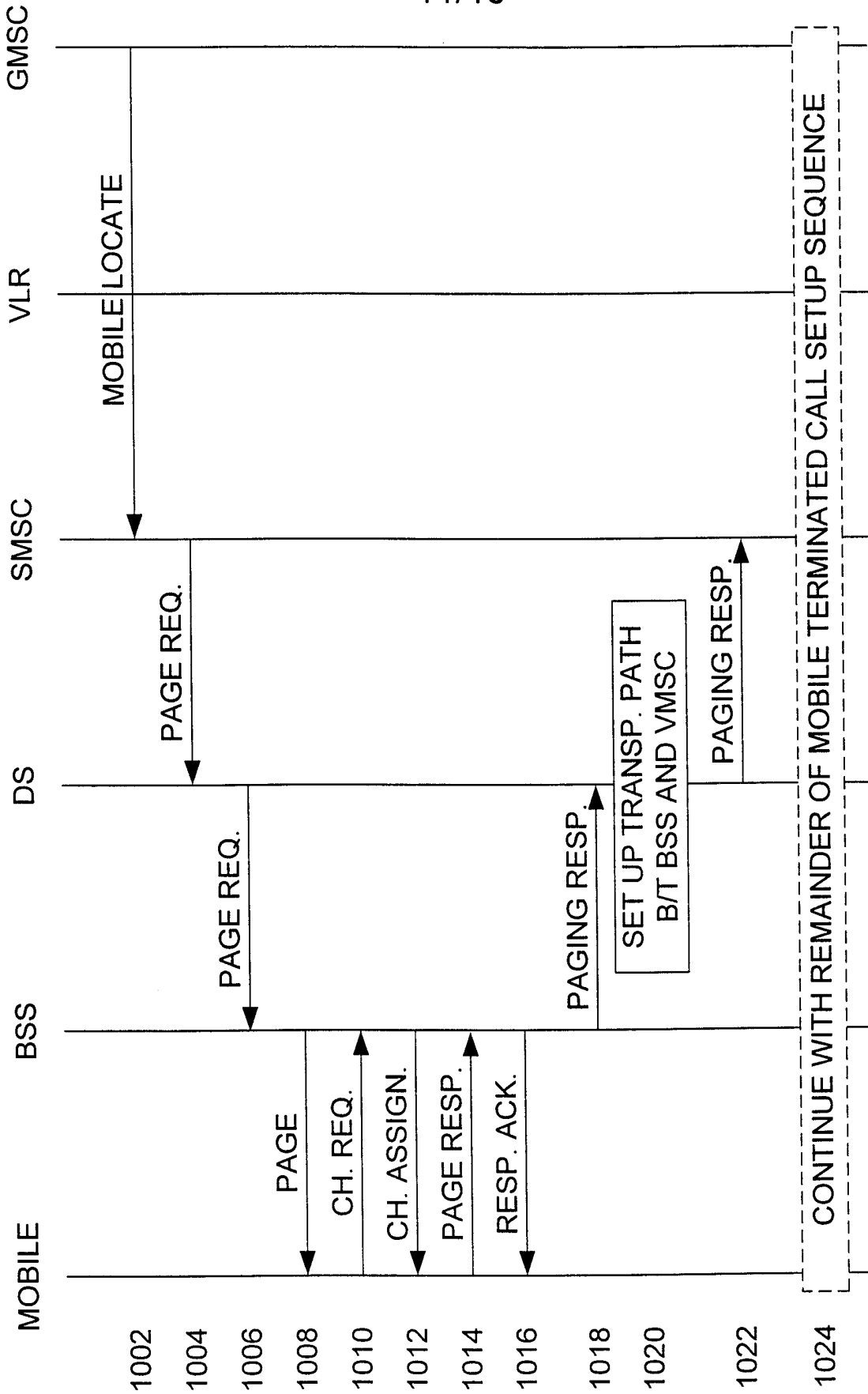


FIG. 10

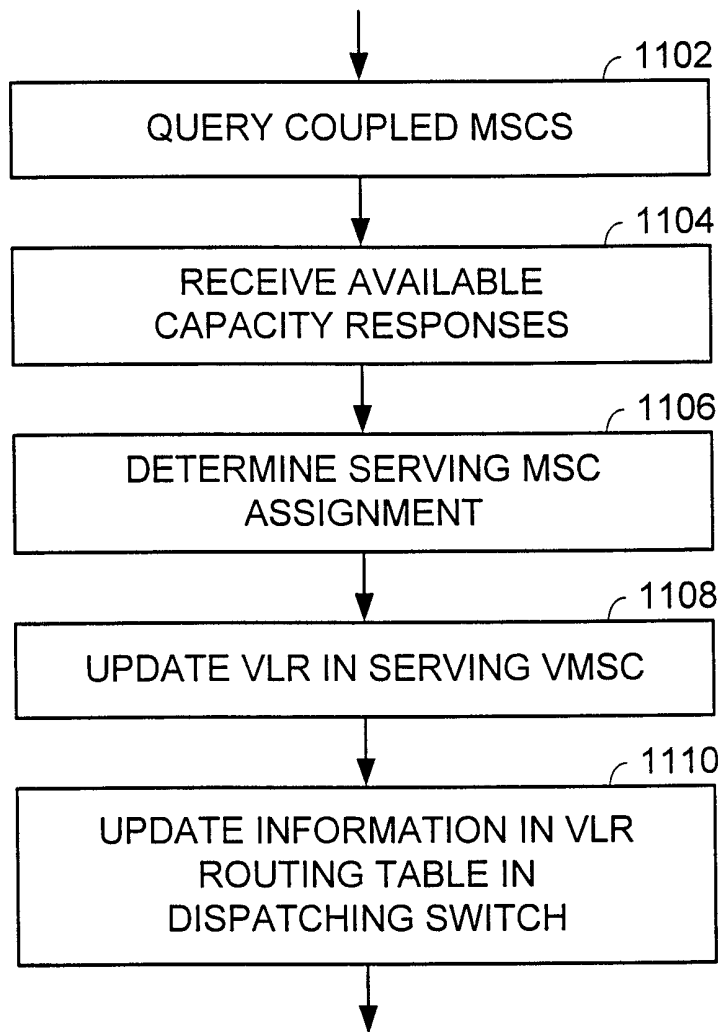


FIG. 11

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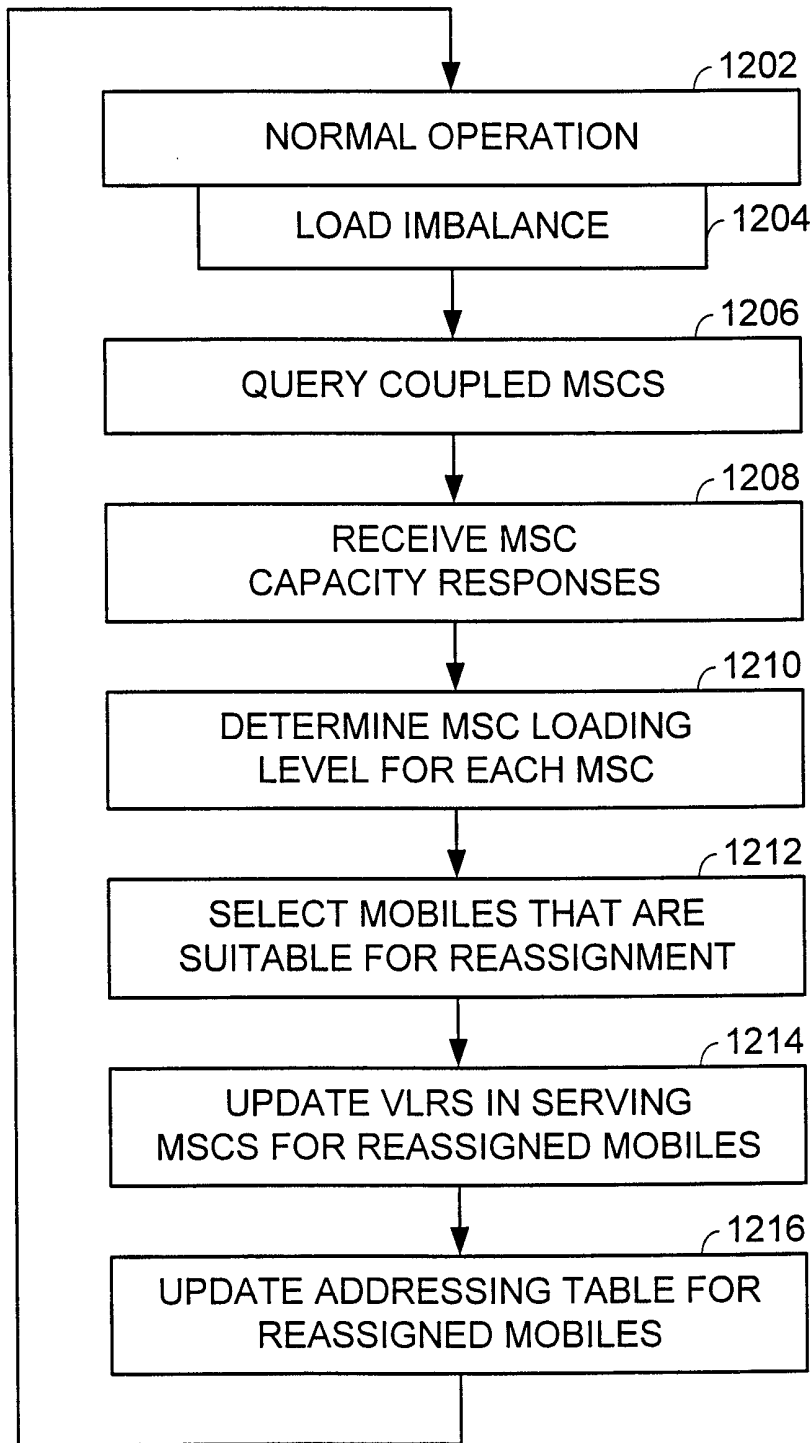


FIG. 12

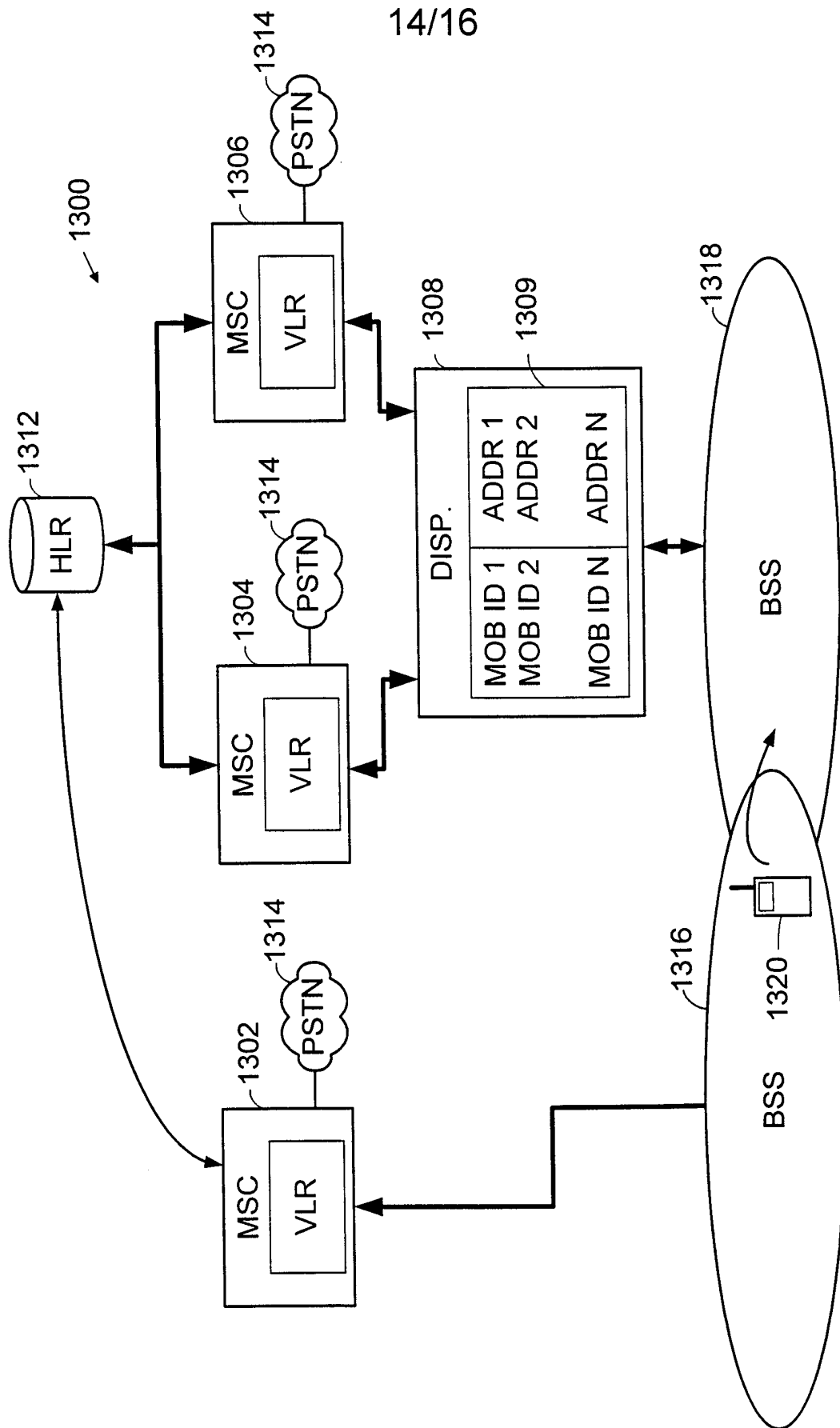


FIG. 13

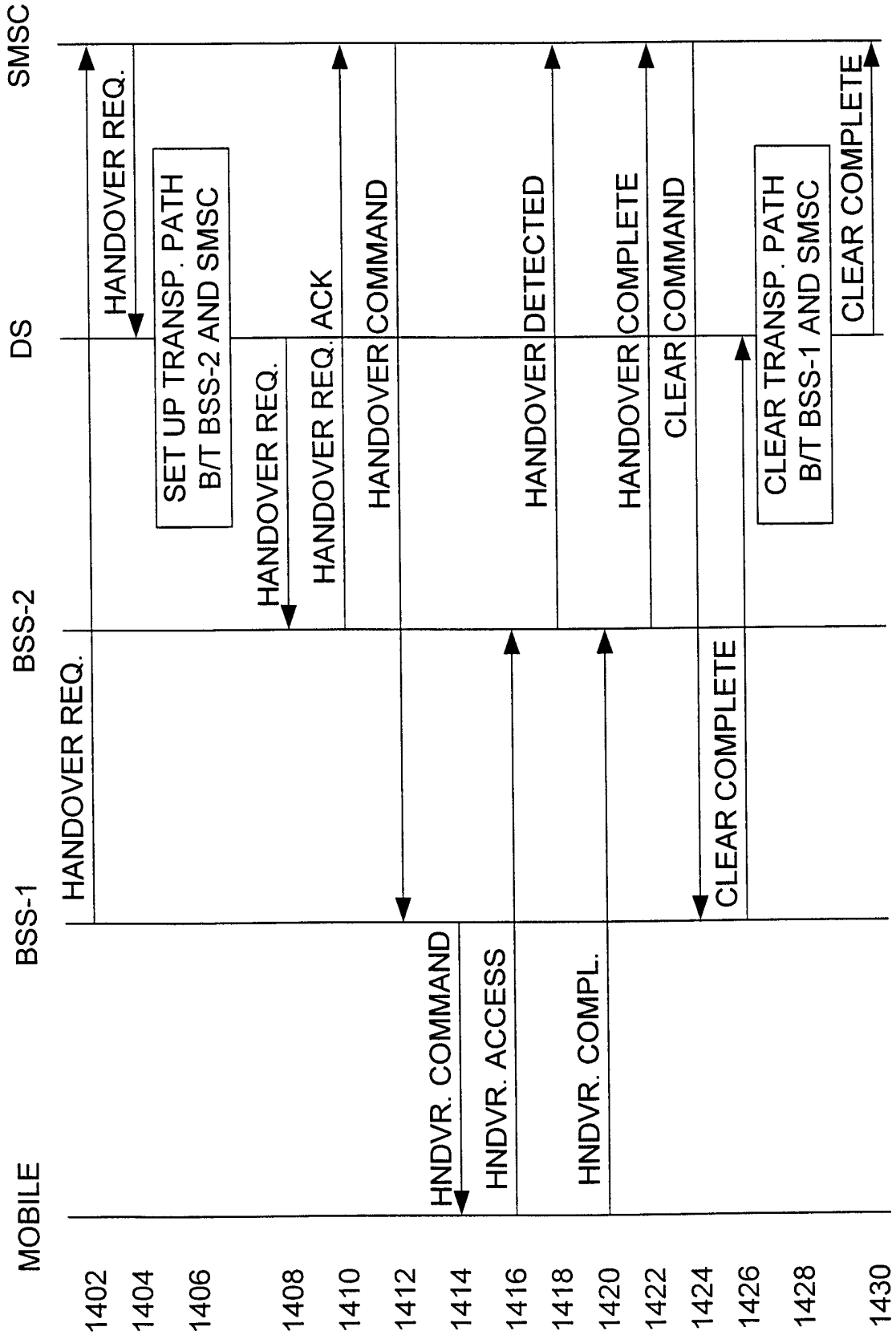


FIG. 14

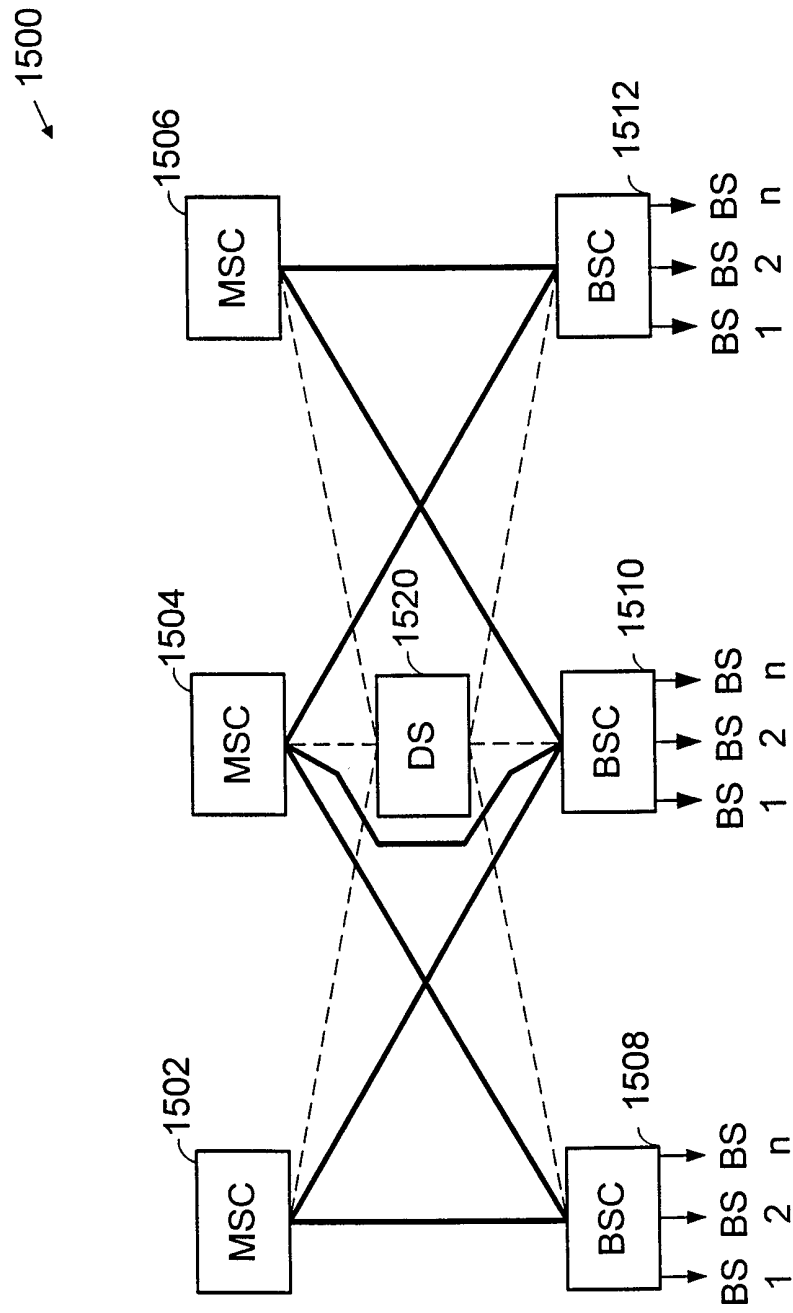


FIG. 15