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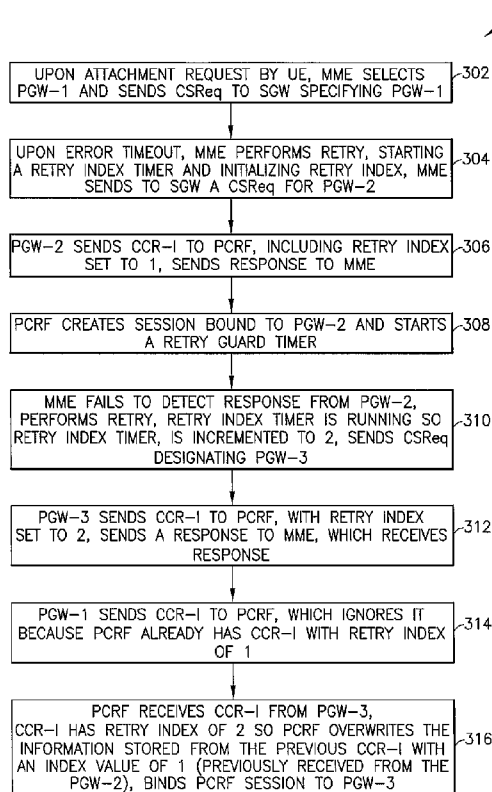
(54) **Title:** METHODS AND APPARATUS FOR TIMING MANAGEMENT

FIG.3

(57) **Abstract:** Systems and techniques for managing service requests for wireless network communication elements, in order to prevent conflicts and confusion between a previously sent request and a retried request sent in due to failure to receive a response to the previously sent request. An initiating element, upon determining that a previously sent service request has not been received, configures a retry status indicator and sends a retried service request to a serving core network element of the wireless communications network, wherein the retried service request includes the retry status indicator. A serving element, upon receiving a service request, examines the service request to determine whether or not the service request includes a retry status indicator and determines whether or not to provide service based on whether or not the service request includes a retry status indicator.



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METHODS AND APPARATUS FOR TIMING MANAGEMENT

TECHNICAL FIELD

The present invention relates generally to radio network communications. More particularly, various embodiments relate to improved systems and techniques for prevention of timing conflicts between entities in a radio communications network.

BACKGROUND

Large radio communication networks comprise numerous elements, including multiple elements of the same type in order to meet capacity requirements and to provide redundancy. In a third generation partnership project (3GPP) long term evolution (LTE) network for example, a network can comprise large numbers of base stations such as eNBs, and these base stations are served by core network elements packet core elements, serving gateways (SGWs), packet gateways (PGWs), authentication, authorization, and accounting (AAA) elements, policy and charging rule function (PCRF) elements, and the like. In order to serve all the users as well as possible, and to provide redundancy in the case of element failures or failure to accomplish an operation, numerous instances of core network elements may be provided, and user devices may, upon failure to connect to a first element, attempt connection to another element of the same type.

SUMMARY

In one embodiment of the invention, a method comprises sending a previous service request to a serving core network element of a wireless communications network, determining that the previous service request has not been received and, upon the determination that the previous service request has not been received, configuring a retry status indicator and sending a retried service request to a serving

core network element of the wireless communications network, wherein the retried service request includes the retry status indicator.

In another embodiment of the invention, a method comprises receiving at a serving core network element of a wireless communications network, a service request sent from an initiating device, examining the service request to determine
5 whether or not the service request includes a retry status indicator, and determining whether or not to provide service based on whether or not the service request includes a retry status indicator.

In another embodiment of the invention, an apparatus comprises at least one
10 processor and memory storing a program of instructions. The memory storing the program of instructions is configured to, with the at least one processor, cause the apparatus to at least send a previous service request to a serving core network element of a wireless communications network, determine that the previous service request has not been received, and, upon the determination that the previous service request
15 has not been received, configure a retry status indicator and sending a retried service request to a serving core network element of the wireless communications network, wherein the retried service request includes the retry status indicator.

In another embodiment of the invention, an apparatus comprises at least one processor and memory storing a program of instructions. The memory storing the
20 program of instructions is configured to, with the at least one processor, cause the apparatus to at least receive at a serving core network element of a wireless communications network, a service request sent from an initiating device, examine the service request to determine whether or not the service request includes a retry status indicator, and determine whether or not to provide service based on whether or
25 not the service request includes a retry status indicator.

In another embodiment of the invention, a computer readable medium stores a program of instructions. Execution of the program of instructions by at least one processor configures an apparatus to at least send a previous service request to a serving core network element of a wireless communications network, determine that
5 the previous service request has not been received, and, upon the determination that the previous service request has not been received, configure a retry status indicator and sending a retried service request to a serving core network element of the wireless communications network, wherein the retried service request includes the retry status indicator.

10 In another embodiment of the invention, a computer readable medium stores a program of instructions. Execution of the program of instructions by at least one processor configures an apparatus to at least receive at a serving core network element of a wireless communications network, a service request sent from an initiating device, examine the service request to determine whether or not the service request
15 includes a retry status indicator, and determine whether or not to provide service based on whether or not the service request includes a retry status indicator.

In another embodiment of the invention, an apparatus comprises means for sending a previous service request to a serving core network element of a wireless communications network, means for determining that the previous service request has
20 not been received and means for, upon the determination that the previous service request has not been received, configuring a retry status indicator and sending a retried service request to a serving core network element of the wireless communications network, wherein the retried service request includes the retry status indicator.

25 In another embodiment of the invention, an apparatus comprises receiving at a

serving core network element of a wireless communications network, a service request sent from an initiating device, means for examining the service request to determine whether or not the service request includes a retry status indicator, and means for determining whether or not to provide service based on whether or not the service request includes a retry status indicator.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a wireless network according to an embodiment of the invention;

Fig. 2 illustrates an operations diagram according to an embodiment of the present invention;

Fig. 3 illustrates a process according to an embodiment of the present invention; and

Fig. 4 illustrates a data processing device that may be used in carrying out one or more embodiments of the present invention.

DETAILED DESCRIPTION

Embodiments of the present invention address problems relating to conflicts presented upon connection attempts to redundant elements in a wireless communication network, particularly attempts to connect to a second element upon failure to connect to a first element. In conventional approaches, a scenario such as the following may occur:

A user equipment (UE) sends a network attachment request. The network's mobility management entity (MME) sends a call session request (CSReq) to a serving gateway (SGW). The SGW forwards the CSReq to a first packet gateway (PGW-1).

The PGW-1 does not respond, or the response is lost, so that the MME does not receive a call setup response (CSResp) with "Request accepted" from the PGW-1,

so the MME retries the CSReq, sending a CSReq to PGW-2. This retry attempt has a successful outcome, with PGW-2 responding and the response being received by the MME.

At this point, the UE now has an internet protocol (IP) address provided by the PGW-2 and performs internet protocol multimedia system (IMS) registration using this IP address. The UE context in the policy and charging rule function (PCRF) is associated with PGW-2. The packet data network information in the AAA is also associated with PGW-2.

While all this is happening, the PGW-1 is processing its queue, and eventually the CSReq that was previously received is ready. The PGW-1 sends a credit control request initialization (CCR-I) to the PCRF. The PCRF assumes that the CCR-I represents a request for a session update and overwrites the UE context with PGW-1 information due to the new (to the PCRF) CCR-I. Similarly, the packet data network (PDN) information in the AAA may also be overwritten with the information associated with the PGW-1 information.

Due to the incorrectness of the UE context in PCRF, the dedicated bearer creation bearer procedure fails and the application function (AF), which in this example is the packet call session control function (P-CSCF) sends a failure notification to the UE when a (for example) voice over LTE (VoLTE) session is needed.

The connection fails, and can be resolved by powering the UE off and then on again, so that a new ATTACH can be made to re-synchronize the UE context in the network.

In this and other scenarios, when the PCRF or AAA receives a request from the PGW (or CCR-I for PCRF, or AAR for AAA), it has no way to determine whether

this request is a stale or obsolete older request, or a newer request. In prior art approaches, the last-received request is process in the hope that it is the newer one. As observed above, if the last-received request is not the newer one, the failure caused by this error may lead to a need to shut down and restart the UE. Such scenarios do
5 not provide for great user satisfaction.

According to one or more embodiments of the invention, a sending entity (that is, a request initiation or forwarding entity such as an MME) may start a retry index timer. As long as the timer is active, each retry will have a retry index included. The first retry will set the index to an initial value and subsequent retries will
10 increment the value (for example, the initial value may be set to one with subsequent retries incrementing the value by 1). The entity receiving a request (such as a PCRF or AAA, of which generally only one exists in an area accessible to a single UE) examines the request for a retry index. If the request includes a retry index, the receiving entity starts a retry guard timer and as long as the timer is running, a higher
15 retry index value (meaning a later attempt) can overwrite a request that has a lower retry index value or no retry index value.

Fig. 1 illustrates a wireless network 100 according to an embodiment of the present invention. The network 100 comprises a number of base stations, implemented as eNBs 102A and 102B, defining cells 104A and 104B, respectively.
20 The eNBs 102A and 102B receive services from a core network 108, which may comprise elements such as a mobility management entity (MME) 110, a serving gateway 111, packet gateways PGW-1, PGW-2, and PGW-3 (112, 114, and 116), a policy charging and rules function entity (PCRF) 118, and an authentication, authorization, and accounting entity (AAA) 120. The network, as represented by the
25 eNBs 102A-102C, serves UEs 122A-122E. The core network 108 provides access

to the Internet 124 and, through the Internet 124, to content such as that provided by content servers 126 and 128. The various elements comprising the core network 108 perform functions to support services needed by the eNBs and the UEs, and external-facing elements of the core network (such as the SGW 111 and the PGWs 112, 114, and 116) receive and relay requests originating at the UEs or eNBs. Elements of the core network 108 respond to service requests, such as Authorization requests, session establishment requests, call service requests, and numerous other types of requests originating at UEs and conveyed by network elements between the UEs and the core network 108, or originating at network elements between the UEs and the core network 108. As noted above and as can be seen in Fig. 1, the core network 108 comprises redundant elements, and a response failure from one element may lead to a request to another element of the same type. Requests within the core network 108 may originate at an originating node (such as the MME 110 and be passed to intermediate nodes such as the SGW 111 and PGWs 112-116. The intermediate nodes prepare their own requests for the receiving or serving nodes 118 or 120.

Fig 2 illustrates a communication and operations diagram 200, showing various core network elements and operations and communications undertaken in supporting communication according to one or more embodiments of the present invention. In the example given here, various elements may be thought of as originating nodes, intermediate nodes, and receiving or serving nodes. As described in more detail below, the MME is an originating node, originating the initial request and directing this request and subsequent retries to intermediate nodes. The PGWs are intermediate nodes, receiving requests from the MME and creating their own requests and sending these to the PCRF, which responds to the different requests.

The diagram 200 illustrates an originating node (MME 202), intermediate nodes (SGW 203, PGW-1 (204A), PGW-2 (204B), PGW-3 (204C)), and a receiving or serving node (PCRF 208). The diagram 200 illustrates an unfulfilled request and subsequent retries by the MME 202, and the operations undertaken to avoid
5 responding to outdated requests. One or more core network elements use a retry index timer and a retry index as described above.

Initially, a UE attaches to the MME 202. At this point, no retry index timer associated with this UE is running. The MME 202 selects the PGW-1 (204A) and sends a CSReq to the SGW 203, so that the CSReq arrives at the PGW-1 (204A).
10 The PGW-1 (204A) queues the request and is unable to process the request for some time, due to a heavy load. The MME 202 times out and begins a retry procedure. At this point, the MME 202 selects the PGW-2 (204B) and prepares a CSReq specifying the PGW2 (204B). The request includes a retry index set to 1. The MME 202 starts a retry index timer.

15 The PGW-2 (204B) processes the request normally and sends a CCR-I to the PCRF with the retry index "1" included. The PCRF 208 creates a session that is bound to PGW-2 (204B). The PCRF 208 notes that the request includes a retry index, and so starts a retry guard timer. The PGW-2 (204B) sends a response, which is not received by the MME 202. The MME 202 thus never receives the response,
20 and determines that it needs to perform another retry, sending a request to the PGW-3 (204C). The MME 202 selects the PGW-3 (204C) and (because the retry index timer is still active) sets the retry index to "2". The MME 202 prepares a CSReq specifying the PGW-3 (204C) including the retry index set to "2", and sends it to the SGW 203 for relaying to the PGW-3 (204C).

25 By this time, the PGW-1 (204A) processes the CSReq and sends a CCR-I to

the PCRF 208. This CCR-I has no retry index value, and the PCRF 208 has already received a CCR-I including a retry index value of "1". Therefore, the new (to the PCRF 208) CCR-I from the PGW-1 (204A) is ignored.

5 The PCRF 208 receives the CCR-I from the PGW-3 (204C), with its retry index value of "3". Because this CCR-I has a higher retry index value than does the previously received CCR-I, the previously received CCR-I (with the retry index value of 1) is overwritten. The PCRF 208 then begins a session bound to the PGW-3 (204C).

Fig. 3 illustrates a process 300 according to one or more embodiments of the
10 present invention, involving steps undertaken by an MME acting as an originating node, PGWs acting as intermediate nodes, and an PCRF acting as a receiving or serving node. At block 302, upon an attachment request by a UE to an MME, the MME selects a PGW-1 and sends a CSReq to an SGW, specifying the PGW-1. At block 304, upon an error time out (caused by failure by the PGW-1 to respond to the
15 CSReq due to a processing delay) the MME performs a retry, starting a retry index timer, setting a retry index to "1" and sending to the CSW a CSReq designated for a PGW-2. At block 306, the PGW-2 sends a CCR-I to a PCRF, with a retry index (set to 1) included, and sends a response to the MME. At block 308, the PCRF creates a session bound to the PGW-2 and (because the request includes a retry index) starts a
20 retry guard timer. At block 310, upon failure to detect the response from the PGW-2, the MME performs a retry. The retry index timer has already been started, so the retry index is set to "2". The MME sends to the CSW a CSReq designated for a PGW-3. At block 312, the PGW-3 sends a CCR-I to the PCRF, with a retry index (set to 2) included, and sends a response to the MME, which receives the
25 response.

At block 314, the PGW-1 sends a CCR-I to the PCRF, which ignores the CCR-I because the retry guard timer is running and the CCR-I lacks any retry index. At block 316, the PCRF receives the CCR-I from the PGW-3. The CCR-I from the PGW-3 has a retry index of “2” which is higher than the retry index of “1” of the current CCR-I, so the PCRF overwrites the information stored from the CCR-I with the index value of 1 (previously received from the PGW-2) and binds a PCRF session to the PGW-3.

Fig. 4 illustrates a data processing element according to one or more embodiments of the present invention. Data processing devices such as the device 400 may be used for various core network elements such as those described above.

The data processing device 400 includes processing means such as at least one data processor (DP) 402, storage such as at least one computer-readable memory (MEM) 404 storing data 406 and at least one computer program (PROG) 408 or other set of executable instructions.

At least one of the PROGs 408 in the data processing device 400 is assumed to include a set of program instructions that, when executed by the associated DP 402, enable the device to operate in accordance with the exemplary embodiments of this invention, as detailed above. In these regards the exemplary embodiments of this invention may be implemented at least in part by computer software stored on the MEM 404, which is executable by the DP 402 of the data processing device 400, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware). An electronic devices implementing these aspects of the invention need not be the entire devices as depicted at Figure4 or may be one or more components of same such as the above described tangibly stored software, hardware, firmware and DP, or a system on a chip SOC or an application specific integrated

circuit ASIC.

In general, the various embodiments of the data processing device can include, but are not limited to cellular network elements. These may include core network elements such as serving gateways, packet gateways, policy charging and rules
5 function elements, mobility management entities, authentication, authorization and accounting entities, and numerous other types of core network elements.

It will be recognized that numerous variant embodiments may be implemented. For example, if a UE needs to perform back to back international mobile subscriber identity (IMSI) attachments, resulting in the use of two different
10 MMEs, the new MME may be assigned a higher index value so that its requests will automatically take priority. For example, if a packet data network (PDN) connect request is received from a new MME after context request and response has been performed with an old MME, the higher index value of the new MME will lead to overwriting of any outstanding request (before the relocation procedure) with the new
15 request.

In one embodiment of the invention, a process comprises providing a core network element from which a request is being sent with information indicating the retry status of the request.

In another embodiment of the invention, the information indicating the retry
20 status comprises an indication of relative priority of the request.

In another embodiment of the invention, the relative priority of the request is indicated by the presence or absence of a retry index number.

In another embodiment of the invention, the relative priority of the request is indicated by the value of a retry index number.

25 In another embodiment of the invention, a request with a retry index number

takes priority over a request with no retry index number and a request with a higher retry index number takes priority over a request with a lower retry index number.

In another embodiment of the invention, a request representing a retry initiates a retry index timer and relative priority is given to requests based on their retry status
5 only during the pendency of the retry index timer.

In another embodiment of the invention, a request with a lower retry status is ignored if a request with a higher retry status has been received.

In another embodiment of the invention, a previously-received request with a lower retry status is discarded and overwritten if a request with a higher retry status is
10 received.

In another embodiment of the invention, an apparatus comprises at least one processor and memory storing a program of instructions. The memory storing the program of instructions is configured to, with the at least one processor, cause the apparatus to at least, upon failure to receive a response to a prior request from a
15 serving core network element, initiate a retry index timer, configure a new request including a retry index, and send the new request including the retry index to the serving core network element.

In another embodiment of the invention, the new request is to a different core network element than the prior request.

20 In another embodiment of the invention, the request is a call session request.

In another embodiment of the invention, the call session request is sent to a designated packet gateway.

In another embodiment of the invention, the apparatus is a mobility management entity.

25 In another embodiment of the invention, an apparatus comprises at least one

processor and memory storing a program of instructions. The memory storing the program of instructions is configured to, with the at least one processor, cause the apparatus to at least, upon receiving a request from a requesting element, examine the request for retry status and, depending at least in part on a retry status of the request,
5 determine whether or not to provide service based on the request.

In another embodiment of the invention, determining whether or not to provide service based on the request comprises ignoring the request if it has a higher retry status than does a previously received request.

In another embodiment of the invention, determining whether or not to
10 provide service based on the request comprises discarding and overwriting a lower status request upon receiving a higher status request.

In another embodiment of the invention, the request is a call session request.

In another embodiment of the invention, the request comprises a credit control request initialization.

15 In another embodiment of the invention, serving the request comprises creating a context for a user device designating a gateway element specified in the request.

In another embodiment of the invention, examining and acting based on retry status of requests is carried out only during the pendency of a timer.

20 In another embodiment of the invention, an apparatus comprises at least one processor and memory storing a program of instructions. The memory storing the program of instructions is configured to, with the at least one processor, cause the apparatus to at least, upon receiving a request from an initiating device including a retry status indication, send a service request to a serving device, wherein the service
25 request includes a retry status request based on the received request.

In another embodiment of the invention, the apparatus is a packet gateway, the received request is a call session request, and the service request is a credit control request initialization.

In another embodiment of the invention, a method comprises, upon failure to
5 receive a response to a prior request from a serving core network element, initiating a retry index timer, configure a new request including a retry index, and send the new request including the retry index to the serving core network element.

In another embodiment of the invention, the new request is to a different core network element than the prior request.

10 In another embodiment of the invention, the request is a call session request.

In another embodiment of the invention, the call session request is sent to a designated packet gateway.

In another embodiment of the invention, the method is performed by a mobility management entity.

15 In another embodiment of the invention, a method comprises, upon receiving a request from a requesting element, examine the request for retry status and, depending at least in part on a retry status of the request, determining whether or not to provide service based on the request.

In another embodiment of the invention, determining whether or not to
20 provide service based on the request comprises ignoring the request if it has a higher retry status than does a previously received request.

In another embodiment of the invention, determining whether or not to provide service based on the request comprises discarding and overwriting a lower status request upon receiving a higher status request.

25 In another embodiment of the invention, the request comprises a credit control

request initialization.

In another embodiment of the invention, serving the request comprises creating a context for a user device designating a gateway element specified in the request.

5 In another embodiment of the invention, examining and acting based on retry status of requests is carried out only during the pendency of a timer.

In another embodiment of the invention, a method comprises, upon receiving a request from an initiating device including a retry status indication, sending a service request to a serving device, wherein the service request includes a retry status request
10 based on the received request.

In another embodiment of the invention, method is performed by a packet gateway, the received request is a call session request, and the service request is a credit control request initialization.

In another embodiment of the invention, a non-transitory computer readable
15 medium stores a program of instructions. Execution of the program of instructions by a processor configures an apparatus to at least, upon failure to receive a response to a prior request from a serving core network element, initiate a retry index timer, configure a new request including a retry index, and send the new request including the retry index to the serving core network element.

20 In another embodiment of the invention, the new request is to a different core network element than the prior request.

In another embodiment of the invention, the request is a call session request.

In another embodiment of the invention, the call session request is sent to a designated packet gateway.

25 In another embodiment of the invention, the apparatus is a mobility

management entity.

In another embodiment of the invention, a non-transitory computer readable medium stores a program of instructions. Execution of the program of instructions by a processor configures an apparatus to at least, upon receiving a request from a
5 requesting element, examine the request for retry status and, depending at least in part on a retry status of the request, determine whether or not to provide service based on the request.

In another embodiment of the invention, determining whether or not to provide service based on the request comprises ignoring the request if it has a higher
10 retry status than does a previously received request.

In another embodiment of the invention, determining whether or not to provide service based on the request comprises discarding and overwriting a lower status request upon receiving a higher status request.

In another embodiment of the invention, the request is a call session request.

15 In another embodiment of the invention, the request comprises a credit control request initialization.

In another embodiment of the invention, serving the request comprises creating a context for a user device designating a gateway element specified in the request.

20 In another embodiment of the invention, examining and acting based on retry status of requests is carried out only during the pendency of a timer.

In another embodiment of the invention, a non-transitory computer readable medium stores a program of instructions. Execution of the program of instructions by a processor configures an apparatus to at least, upon receiving a request from an
25 initiating device including a retry status indication, send a service request to a serving

device, wherein the service request includes a retry status request based on the received request.

In another embodiment of the invention, the apparatus is a packet gateway, the received request is a call session request, and the service request is a credit control
5 request initialization.

While various exemplary embodiments have been described above it should be appreciated that the practice of the invention is not limited to the exemplary embodiments shown and discussed here. Various modifications and adaptations to the foregoing exemplary embodiments of this invention may become apparent to those
10 skilled in the relevant arts in view of the foregoing description.

Further, some of the various features of the above non-limiting embodiments may be used to advantage without the corresponding use of other described features.

The foregoing description should therefore be considered as merely illustrative of the principles, teachings and exemplary embodiments of this invention, and not in
15 limitation thereof.

I claim:

1. A method comprising:
sending a previous service request to a serving core network element of a wireless communications network;
determining that the previous service request has not been received; and
upon the determination that the previous service request has not been received, configuring a retry status indicator and sending a retried service request to a serving core network element of the wireless communications network, wherein the retried service request includes the retry status indicator.
2. The method of claim 1, wherein the retry status indicator includes a retry index with a retry index number indicating the relative position of the retried service request in a sequence of retried service requests following a failure to receive a response.
3. The method of claim 1 or 2, wherein the method is performed by a mobility management entity.
4. The method of claim 1, 2, or 3, wherein the service request is a call service request.
5. The method of claim 1, 2, or 3, wherein the service request is a session establishment request.
6. The method of claim 1, 2, or 3, wherein the service request is an Authorization request.
7. The method of claim any of claims 1-6, wherein configuring the retry status indicator comprises starting a retry index timer and, for each retried service request configured while the retry index timer is active, including a retry index number in the retry status indicator.

8. The method of claim any of claims 1-6, wherein the retried service request is sent to a different serving element than the previous service request.

9. A method comprising:

receiving at a serving core network element of a wireless communications network, a service request sent from an initiating device;

examining the service request to determine whether or not the service request includes a retry status indicator; and

determining whether or not to provide service based on whether or not the service request includes a retry status indicator.

10. The method of claim 9, wherein determining whether or not the service request is a retried service request is performed only during pendency of a timer.

11. The method of claim 9 or 10, wherein examining the retried service request for a retry status indicator comprises examining the retry status indicator for a retry index.

12. The method of claim 11, wherein the retry index comprises a retry index number indicating the sequence of the retried service request in a sequence of retried service requests, and wherein the most recent retried service request in the sequence is given priority.

13. The method of claim 9, 10, 11, or 12, wherein determining whether to provide service based on whether or not the service request includes a retry status indicator comprises:

upon receiving a service request including a retry status indicator, rejecting a previous service request that does not include a retry status indicator.

14. The method of claim 9, 10, 11, or 12, wherein determining whether to provide service based on whether or not the service request includes a retry status indicator comprises:

upon receiving a service request not including a retry status indicator, rejecting the

service request.

15. The method of claim 9, 10, 11, or 12, wherein the service request is a session establishment request and wherein the method further comprises, upon receiving a retried session establishment request including a retry status indicator, releasing a current session established in response to a previous session establishment request without a retry status indicator and establishing a session request in response to the retried session establishment request.

16. The method of claim 9, 10, 11, or 12, wherein the service request is a session establishment request and wherein the method further comprises, upon receiving a session establishment request not including a retry status indicator, rejecting the session establishment request.

17. An apparatus comprising:
at least one processor;
memory storing a program of instructions;
wherein the memory storing the program of instructions is configured to, with the at least one processor, cause the apparatus to at least:
send a previous service request to a serving core network element of a wireless communications network;
determine that the previous service request has not been received; and
upon the determination that the previous service request has not been received, configure a retry status indicator and sending a retried service request to a serving core network element of the wireless communications network, wherein the retried service request includes the retry status indicator.

18. The apparatus of claim 17, wherein the retry status indicator includes a retry index

with a retry index number indicating the relative position of the retried service request in a sequence of retried service requests following a failure to receive a response.

19. The apparatus of claim 17 or 18, wherein the apparatus is a mobility management entity.

20. The apparatus of claim 17, 18, or 19, wherein the service request is a call service request.

21. The apparatus of claim 17, 18, or 19, wherein the service request is a session establishment request.

22. The apparatus of claim 17, 18, or 19, wherein the service request is an Authorization request.

23. The apparatus of any of claims 17-19, wherein configuring the retry status indicator comprises starting a retry index timer and, for each retried service request configured while the retry index timer is active, including a retry index number in the retry status indicator.

24. The apparatus of any of claims 17-19, wherein the retried service request is sent to a different serving element than the previous service request.

25. A apparatus comprising:
at least one processor;
memory storing a program of instructions;
wherein the memory storing the program of instructions is configured to, with the at least one processor, cause the apparatus to at least:
receive at a serving core network element of a wireless communications network, a service request sent from an initiating device;
examine the service request to determine whether or not the service request includes a

retry status indicator; and

determine whether or not to provide service based on whether or not the service request includes a retry status indicator.

26. The apparatus of claim 25, wherein determining whether or not the service request is a retried service request is performed only during pendency of a timer.

27. The apparatus of claim 25 or 26, wherein examining the retried service request for a retry status indicator comprises examining the retry status indicator for a retry index.

28. The apparatus of claim 27, wherein the retry index comprises a retry index number indicating the sequence of the retried service request in a sequence of retried service requests, and wherein the most recent retried service request in the sequence is given priority.

29. The apparatus of claim 25, 26, 27, or 28, wherein determining whether to provide service based on whether or not the service request includes a retry status indicator comprises:

upon receiving a service request including a retry status indicator, rejecting a previous service request that does not include a retry status indicator.

30. The apparatus of claim 25, 26, 27, or 28, wherein determining whether or not to provide service based on whether or not the service request includes a retry status indicator comprises:

upon receiving a service request not including a retry status indicator, rejecting the service request.

31. The apparatus of claim 25, 26, 27, or 28, wherein the service request is a session establishment request and wherein the apparatus is further caused, upon receiving a retried session establishment request including a retry status indicator, to release a current session established in response to a previous session establishment request without a retry status

indicator and to establish a session request in response to the retried session establishment request.

32. The apparatus of claim 25, 26, 27, or 28, wherein the service request is a session establishment request and wherein the apparatus is further caused to, upon receiving a session establishment request not including a retry status indicator, reject the session establishment request.

33. A computer readable medium storing a program of instructions, execution of which by at least one processor configures an apparatus to at least:

send a previous service request to a serving core network element of a wireless communications network;

determine that the previous service request has not been received; and

upon the determination that the previous service request has not been received, configure a retry status indicator and sending a retried service request to a serving core network element of the wireless communications network, wherein the retried service request includes the retry status indicator.

34. The computer readable medium of claim 33, wherein the retry status indicator includes a retry index with a retry index number indicating the relative position of the retried service request in a sequence of retried service requests following a failure to receive a response.

35. The computer readable medium of claim 33 or 34, wherein the apparatus is a mobility management entity.

36. The computer readable medium of claim 33, 34, or 35, wherein the service request is a call service request.

37. The computer readable medium of claim 33, 34, or 35, wherein the service

request is a session establishment request.

38. The computer readable medium of claim 33, 34, or 35, wherein the service request is an Authorization request.

39. The computer readable medium of any of claims 33-38, wherein configuring the retry status indicator comprises starting a retry index timer and, for each retried service request configured while the retry index timer is active, including a retry index number in the retry status indicator.

40. The computer readable medium of any of claims 33-38, wherein the retried service request is sent to a different serving element than the previous service request.

41. A computer readable medium comprising:
at least one processor;
memory storing a program of instructions;
wherein the memory storing the program of instructions is configured to, with the at least one processor, cause the apparatus to at least:
receiving at a serving core network element of a wireless communications network, a service request sent from an initiating device;
examining the service request to determine whether or not the service request includes a retry status indicator; and
determining whether or not to provide service based on whether or not the service request includes a retry status indicator.

42. The computer readable medium of claim 41, wherein determining whether or not the service request is a retried service request is performed only during pendency of a timer.

43. The computer readable medium of claim 41 or 42, wherein examining the retried

service request for a retry status indicator comprises examining the retry status indicator for a retry index.

44. The computer readable medium of claim 41, 42, or 43, wherein the retry index comprises a retry index number indicating the sequence of the retried service request in a sequence of retried service requests, and wherein the most recent retried service request in the sequence is given priority.

45. The computer readable medium of claim 41, 42, 43, or 44, wherein determining whether or not to provide service based on whether or not the service request includes a retry status indicator comprises:

upon receiving a service request including a retry status indicator, rejecting a previous service request that does not include a retry status indicator.

46. The computer readable medium of claim 41, 42, 43, or 44, wherein determining whether or not to provide service based on whether or not the service request includes a retry status indicator comprises:

upon receiving a service request not including a retry status indicator, rejecting the service request.

47. The computer readable medium of claim 41, 42, 43, or 44, wherein the service request is a session establishment request and wherein the apparatus is further configured, upon receiving a retried session establishment request including a retry status indicator, to release a current session established in response to a previous session establishment request without a retry status indicator and to establish a session request in response to the retried session establishment request.

48. The computer readable medium of claim 41, 42, 43, or 44, wherein the service

request is a session establishment request and wherein the apparatus is further configured to, upon receiving a session establishment request not including a retry status indicator, reject the session establishment request.

49. An apparatus comprising:

means for sending a previous service request to a serving core network element of a wireless communications network;

means for determining that the previous service request has not been received; and

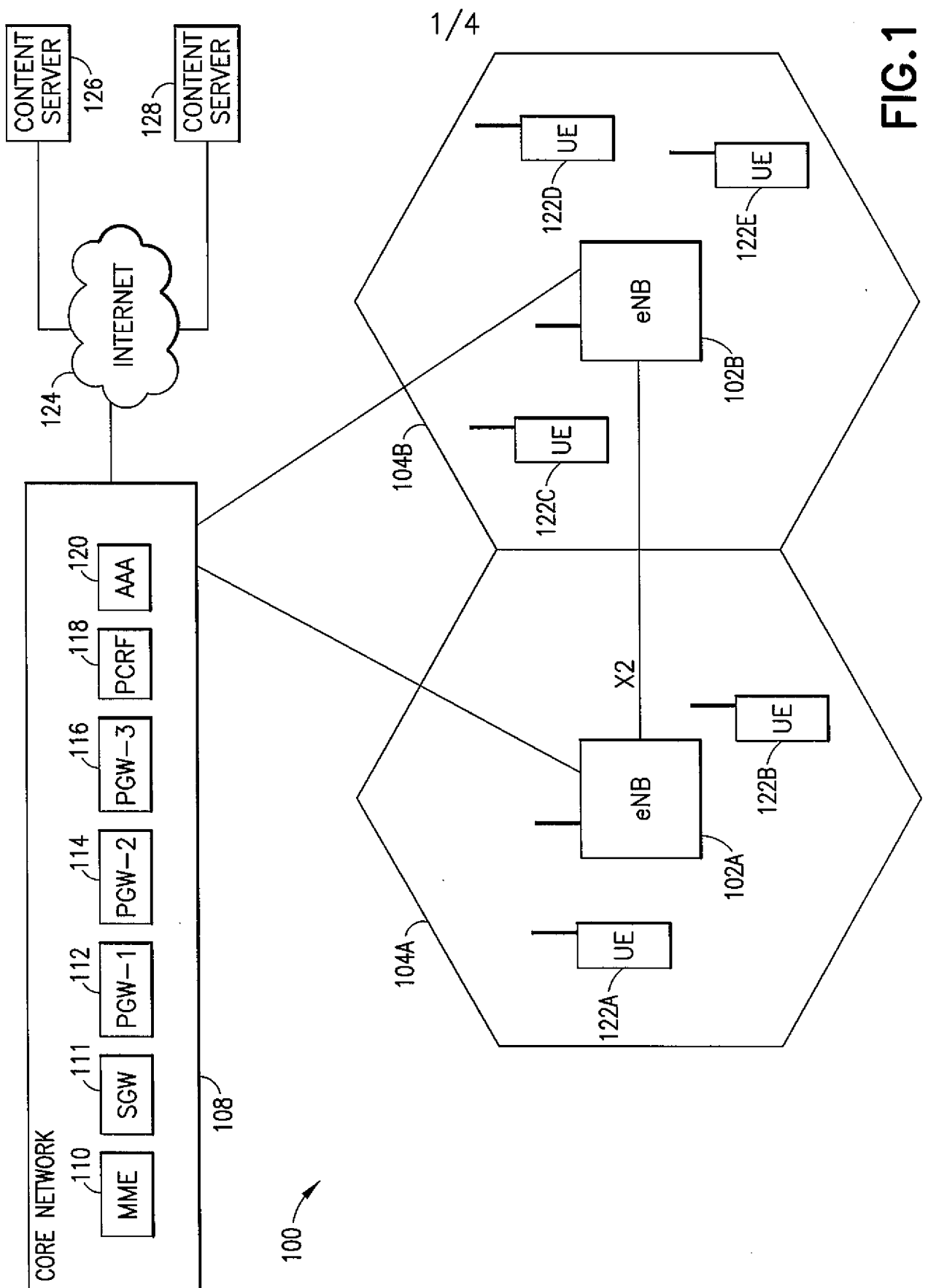
means for, upon the determination that the previous service request has not been received, configuring a retry status indicator and sending a retried service request to a serving core network element of the wireless communications network, wherein the retried service request includes the retry status indicator.

50. An apparatus comprising:

means for receiving at a serving core network element of a wireless communications network, a service request sent from an initiating device;

means for examining the service request to determine whether or not the service request includes a retry status indicator; and

means for determining whether or not to provide service based on whether or not the service request includes a retry status indicator.



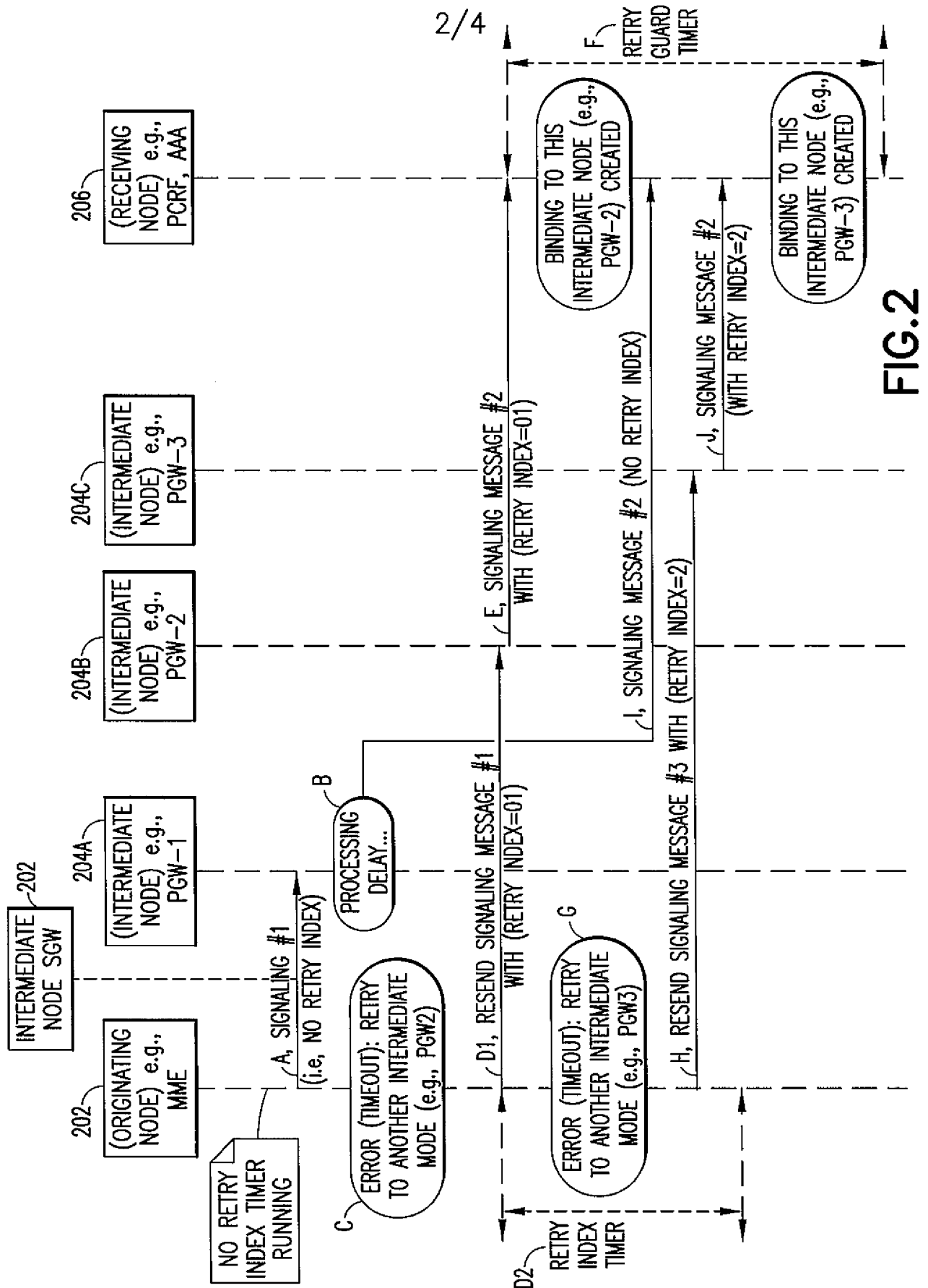


FIG.2

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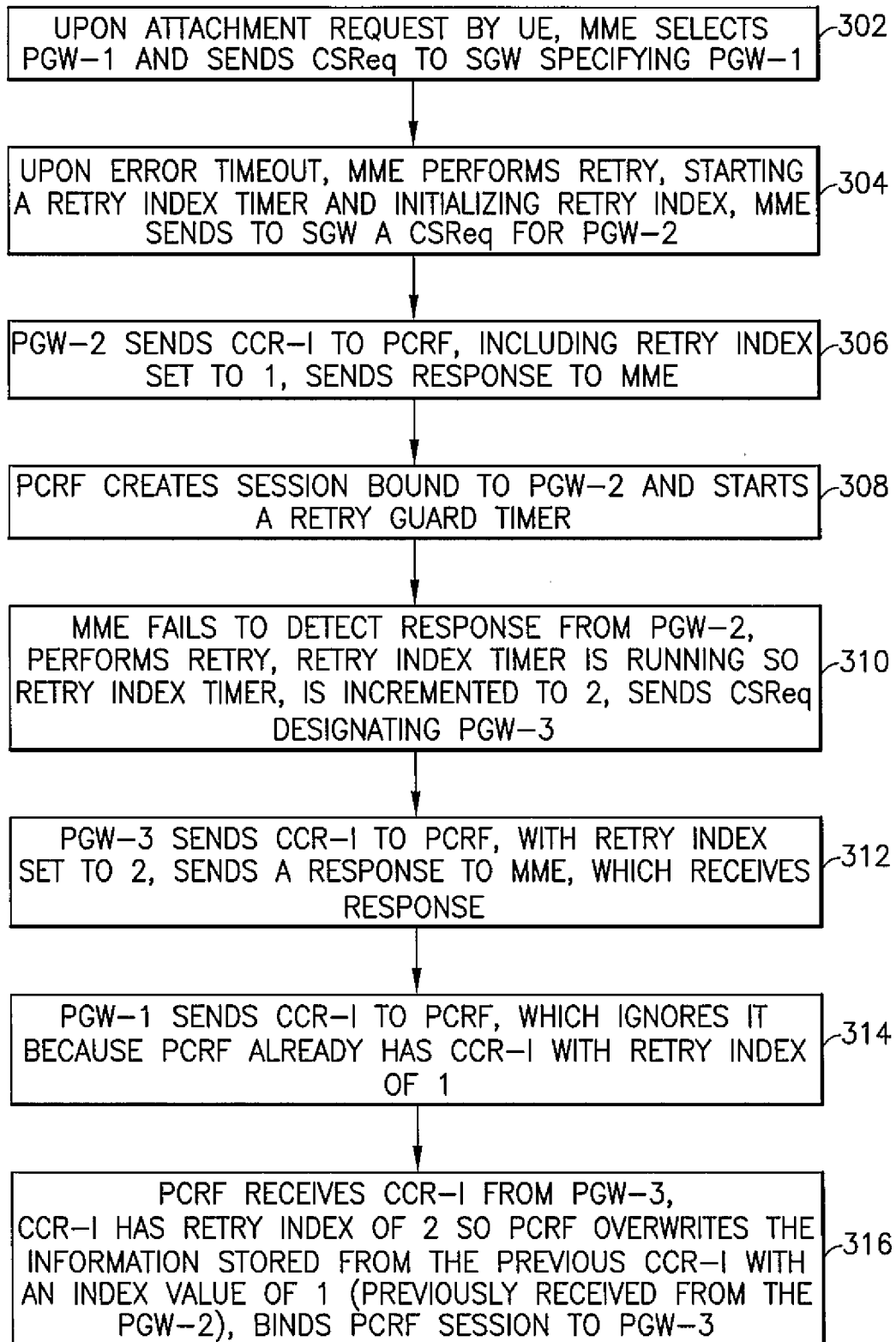
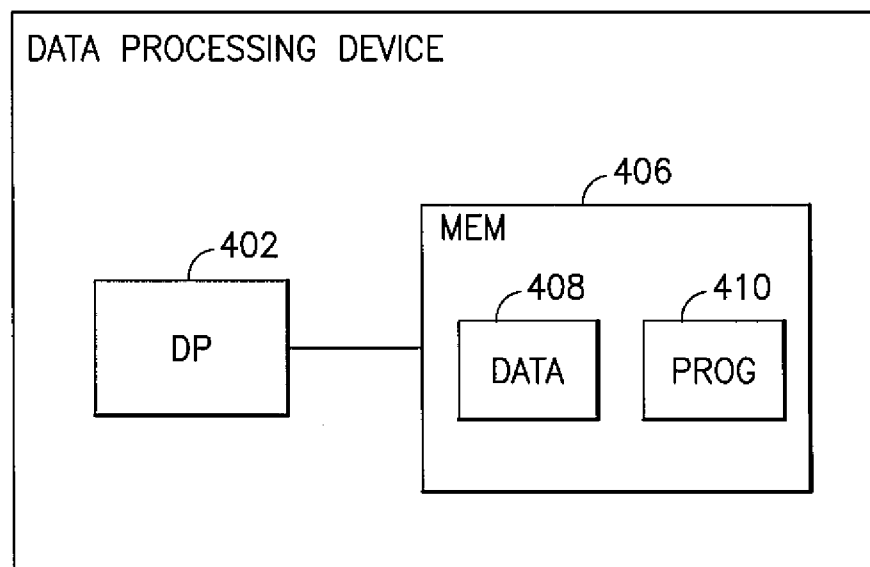


FIG.3

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**FIG.4**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/028697

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - G06F 15/16 (2015.01) CPC - G06F 15/16 (2015.04) According to International Patent Classification (IPC) or to both national classification and IPC																							
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC(8) - G06F 15/16, 15/173; H04W 76/00 (2015.01) USPC - 370/225; 709/206, 223 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched CPC - G06F 15/16, 15/173; H04W 76/00 (2015.04) (keyword delimited) Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Orbit, Google Patents, Google Scholar, Google. Search terms used: sending, previous service request, serving core, network, element, wireless, retry, flag, index																							
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>US 2010/0030880 A1 (JOSHI et al) 04 February 2010 (04.02.2010) entire document</td> <td>1-3, 10-12, 17-19, 26-28, 33-35, 42, 43, 49</td> </tr> <tr> <td>Y</td> <td></td> <td>9,25,41,50</td> </tr> <tr> <td>Y</td> <td>US 2010/0312846 A1 (LU et al) 09 December 2010 (09.12.2010) entire document</td> <td>1-3, 17-19, 33-35, 49</td> </tr> <tr> <td>Y</td> <td>US 2012/0039167 A1 (SWAMINATHAN et al) 16 February 2012 (16.02.2012) entire document</td> <td>2, 10-12, 18, 26-28, 34, 42, 43</td> </tr> <tr> <td>A</td> <td>US 8,578,035 B2 (MIKLOS et al) 05 November 2013 (05.11.2013) entire document</td> <td>1-3, 9-12, 17-19, 25-28, 33-35, 41-43, 49, 50,</td> </tr> <tr> <td>A</td> <td>US 2012/0281566 A1 (PELLETIER et al) 08 November 2012 (08.11.2012) entire document</td> <td>1-3, 9-12, 17-19, 25-28, 33-35, 41-43, 49, 50,</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	US 2010/0030880 A1 (JOSHI et al) 04 February 2010 (04.02.2010) entire document	1-3, 10-12, 17-19, 26-28, 33-35, 42, 43, 49	Y		9,25,41,50	Y	US 2010/0312846 A1 (LU et al) 09 December 2010 (09.12.2010) entire document	1-3, 17-19, 33-35, 49	Y	US 2012/0039167 A1 (SWAMINATHAN et al) 16 February 2012 (16.02.2012) entire document	2, 10-12, 18, 26-28, 34, 42, 43	A	US 8,578,035 B2 (MIKLOS et al) 05 November 2013 (05.11.2013) entire document	1-3, 9-12, 17-19, 25-28, 33-35, 41-43, 49, 50,	A	US 2012/0281566 A1 (PELLETIER et al) 08 November 2012 (08.11.2012) entire document	1-3, 9-12, 17-19, 25-28, 33-35, 41-43, 49, 50,
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☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.																							
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family																							
Date of the actual completion of the international search 13 July 2015		Date of mailing of the international search report 05 AUG 2015																					
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300		Authorized officer Blaine Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774																					

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/028697

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-8, 13-16, 20-24, 29-32, 36-40, 44-48
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.