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(54) Title: METHODS, SYSTEMS, AND COMPUTER READABLE MEDIA FOR INTER-DIAMETER-MESSAGE PROCESSOR ROUTING

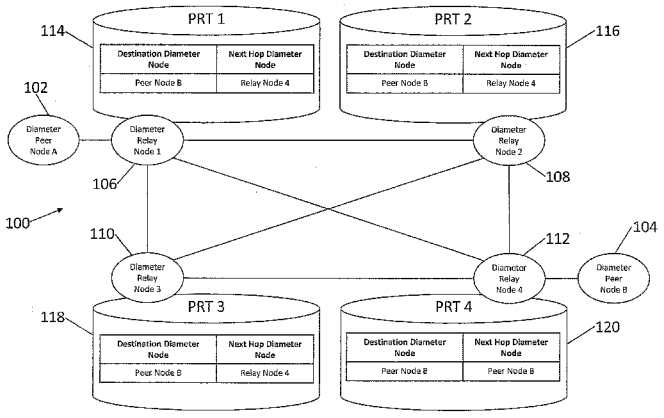


FIG. 1

(57) Abstract: According to one aspect, the subject matter described herein includes a method for routing Diameter messages. The method includes steps occurring at a Diameter signaling router (DSR) comprising a plurality of Diameter message processors. The method also includes receiving, by a first of the plurality of Diameter message processors and from a first Diameter node, a Diameter message, wherein the Diameter message is received via a first Diameter connection. The method further includes determining, by the first Diameter message processor, a next-hop Diameter node for the Diameter message. The method further includes communicating, by the first of the plurality of Diameter message processors and to a second of the plurality of Diameter message processors, the Diameter message. The method further includes communicating, by the second Diameter message processor and to the next-hop Diameter node, the Diameter message, wherein the Diameter message is communicated via a second Diameter connection.

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DESCRIPTION

METHODS, SYSTEMS, AND COMPUTER READABLE MEDIA FOR INTER-DIAMETER-MESSAGE PROCESSOR ROUTING

PRIORITY CLAIM

This application claims the benefit of U.S. Provisional Patent Application Serial No. 61/304,310, filed February 12, 2010; the disclosure of which is incorporated herein by reference in its entirety.

STATEMENT OF INCORPORATION BY REFERENCE

The disclosures of each of the following commonly-owned, co-pending U.S. Patent Applications filed on February 11, 2011 are hereby incorporated herein by reference in their entireties:

"Methods, Systems, And Computer Readable Media For Source Peer Capacity-Based Diameter Load Sharing" Attorney Docket No. 1322/399/3 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Inter-Message Processor Status Sharing," Attorney Docket No. 1322/399/4 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Providing Priority Routing At A Diameter Node," Attorney Docket No. 1322/399/5 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Providing Peer Routing At A Diameter Node," Attorney Docket No. 1322/399/6/2 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Providing Origin Routing At A Diameter Node," Attorney Docket No. 1322/399/7 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Providing Local Application Routing At A Diameter Node," Attorney Docket No. 1322/399/8 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Answer-Based Routing Of Diameter Request Messages," Attorney Docket No. 1322/399/9 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Performing Diameter Answer Message-Based Network Management At A Diameter Signaling Router (DSR)," Attorney Docket No. 1322/399/10 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Multi-Interface Monitoring And Correlation Of Diameter Signaling Information," Attorney Docket No. 1322/399/11 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Diameter Protocol Harmonization," Attorney Docket No. 1322/399/12 (Serial No. not yet assigned);

"Methods, Systems, And Computer Readable Media For Diameter Network Management," Attorney Docket No. 1322/399/13 (Serial No. not yet assigned); and

"Methods, Systems, And Computer Readable Media For Diameter Application Loop Prevention," Attorney Docket No. 1322/399/14 (Serial No. not yet assigned).

TECHNICAL FIELD

The subject matter described herein relates to inter-Diameter-message processor routing. More specifically, the subject matter relates to methods, systems, and computer readable media for inter-Diameter-message processor routing.

BACKGROUND

The Diameter protocol is a next generation authentication, authorization, and accounting (AAA) protocol. The Diameter base protocol is defined in IETF RFC 3588, the disclosure of which is incorporated by reference herein in its entirety. Commonly used within the Internet multimedia subsystem (IMS) architecture, the Diameter protocol was derived from the remote authentication dial-in user service (RADIUS) protocol.

Historically, the RADIUS protocol was employed by Internet service providers (ISPs) to provide a secure communication channel between an ISP's access server and a secure location where user credential information was stored, e.g., a lightweight directory access protocol (LDAP) server. While the RADIUS protocol provided a standardized AAA exchange protocol, the emergence of new technologies and applications necessitated the development of a protocol capable of meeting ever-changing demands. Diameter aims to extend the standardized approach of RADIUS while providing expanded functionality and remaining open to future development.

The above-referenced Diameter RFC does not specify an architecture for Diameter routing or processing nodes. Likewise, the standards do not specify a method for inter-message processor routing when a Diameter element includes a distributed architecture. Accordingly, a need exists for methods, systems, and computer readable media for inter-Diameter-message processor routing.

SUMMARY

According to one aspect, the subject matter described herein includes a method for routing Diameter messages. The method includes steps occurring at a Diameter signaling router (DSR) comprising a plurality of Diameter message processors. The method includes receiving, by a first of the plurality of Diameter message processors and from a first Diameter node, a Diameter message, wherein the Diameter message is received via a first Diameter connection. The method further includes determining, by the first of the plurality of Diameter message processors, a next-hop Diameter node for the Diameter message. The method further includes communicating, by the first Diameter message processor and to a second of the plurality of Diameter message processors, the Diameter message. The method further includes communicating, by the second Diameter message processor and to the next-hop Diameter node, the Diameter message, wherein the Diameter message is communicated via a second Diameter connection.

According to another aspect, the subject matter described herein includes a system for routing Diameter messages. The system includes a Diameter signaling router. The Diameter signaling router includes first and second Diameter message processors. The first Diameter message processor is configured to: receive, from a first Diameter node and via a first Diameter connection, a Diameter message; determine a next-hop Diameter node for the Diameter message; and communicate, to the second Diameter message processor, the Diameter message. The second Diameter message processor is configured to communicate to the next-hop Diameter node, via a second Diameter connection, the Diameter message.

According to another aspect, the subject matter described herein includes a system for routing Diameter messages. The system includes a first Diameter node and a second Diameter node. The system further includes a DSR, wherein the DSR appears to the first Diameter node as a Diameter peer having a first Diameter identity and the DSR appears to the second Diameter node as a Diameter peer having a second Diameter identity, the first and second Diameter identities being different from each other.

As used herein, the term "node" refers to a physical computing platform including one or more processors and memory.

The subject matter described herein can be implemented in software in combination with hardware and/or firmware. For example, the subject matter described herein may be implemented in software executed by one or more processors. In one exemplary implementation, the subject matter described herein may be implemented using a non-transitory computer readable medium having stored thereon computer executable instructions that when executed by the processor of a computer control the computer to perform steps. Exemplary computer readable media suitable for implementing the subject matter described herein include non-transitory computer readable media, such as disk memory devices, chip memory devices, programmable logic devices, and application specific integrated circuits. In addition, a computer readable medium that implements the subject matter described herein may be located on a single device or

computing platform or may be distributed across multiple devices or computing platforms.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter described herein will now be explained with reference to the accompanying drawings of which:

Figure 1 is a network diagram illustrating a Diameter networking environment which implements Diameter relay nodes for routing Diameter messages between Diameter nodes;

Figure 2 is a message flow diagram illustrating the routing of a Diameter message in a Diameter networking environment which implements Diameter relay nodes for routing Diameter messages between Diameter nodes;

Figure 3 is a network diagram illustrating an exemplary network that includes a Diameter signaling router (DSR) which includes multiple Diameter message processors (MPs) that utilize common routing information stored at each MP to route Diameter messages according to an embodiment of the subject matter described herein;

Figure 4 is a network diagram illustrating an exemplary network that includes a DSR which includes multiple MPs that utilize common routing information stored in a shared repository to route Diameter messages according to an embodiment of the subject matter described herein;

Figure 5 is a network diagram illustrating in more detail exemplary MPs for routing Diameter messages according to an embodiment of the subject matter described herein;

Figure 6 is a network diagram illustrating an exemplary inter-MP message format used for routing Diameter messages between Diameter message processors using a non-Diameter protocol according to an embodiment of the subject matter described herein;

Figure 7 is a message flow diagram illustrating the routing of a Diameter message according to an embodiment of the subject matter described herein;

Figure 8 illustrates an exemplary peer routing table (PRT) for routing Diameter messages according to an embodiment of the subject matter described herein;

Figure 9 illustrates an exemplary route list table (RLT) for routing Diameter messages according to an embodiment of the subject matter described herein;

Figure 10 illustrates a table listing advantages associated with routing Diameter messages according to an embodiment of the subject matter described herein;

Figure 11 is a flow chart illustrating an exemplary process for routing Diameter messages according to an embodiment of the subject matter described herein; and

Figure 12 is a network diagram illustrating an exemplary network that includes a DSR which appears to have different Diameter identities from the perspective of different Diameter peer nodes according to an embodiment of the subject matter described herein.

DETAILED DESCRIPTION

Methods, systems, and computer readable media for inter-Diameter-message processor routing are provided.

In general, Diameter messages may be routed utilizing Diameter routing agents. Diameter routing agents may route Diameter messages from a network element towards their proper Diameter realm and destination. Additionally, Diameter routing agents may provide relay, proxy, redirect, and translation services. Figure 1 is a network diagram illustrating a Diameter networking environment which implements Diameter relay nodes for routing Diameter messages between Diameter nodes. Referring to Figure 1, network **100** may include Diameter peer nodes **102** and **104**. Network **100** may further include Diameter relay nodes **106**, **108**, **110**, and **112**. Diameter relay nodes **106**, **108**, **110**, and **112** may respectively utilize distinct routing information stored in distinct peer routing tables **114**, **116**, **118**, and **120**. Peer routing tables **114**, **116**, **118**, and **120** may specify a "next hop" Diameter node for a given destination Diameter node. For example, if a

Diameter message destined for Diameter peer node "B" arrives at Diameter relay node **106**, PRT **114** specifies the "next hop" Diameter node as Diameter relay node **112**. Similarly, if a Diameter message destined for Diameter per node "B" arrives at Diameter relay node **112**, PRT **120** specifies the "next hop" Diameter node as Diameter peer node **104**, the Diameter message's destination.

Figure 2 is a message flow diagram illustrating the routing of a Diameter message in a Diameter networking environment which implements Diameter relay nodes for routing Diameter messages between Diameter nodes. Referring to Figure 2, at step 1, Diameter peer node A **102** may send to Diameter relay node **106** a Diameter protocol request message destined for Diameter peer node B **104**. Diameter relay node **106** may perform a Diameter routing lookup utilizing the routing information stored in PRT **114**. The routing information stored in PRT **114** specifies that a Diameter message destined for Diameter peer node B **104** has a next hop Diameter node of Diameter relay node **112**. At step 2, Diameter relay node **106** may send to Diameter relay node **112** the Diameter protocol request message destined for Diameter peer node B **104**. Diameter relay node **112** may perform a Diameter routing lookup utilizing the routing information stored in PRT **120**. The routing information stored in PRT **120** specifies that a Diameter message destined for Diameter peer node B **104** has a next hop Diameter node of Diameter peer node **104**, the destination of the Diameter protocol request message.

As Figures 1 and 2 illustrate, three "hops" are required in order for a Diameter protocol message destined for Diameter peer node "B" to progress from Diameter peer node "A" **102** through Diameter networking environment **100** to Diameter peer node "B" **104**: (1) from Diameter peer node **102** to Diameter relay node **106**; (2) from Diameter relay node **106** to Diameter relay node **112**; and (3) from Diameter relay node **112** to Diameter peer node **104**. Importantly, not only are three hops required, but two Diameter routing lookups must be performed: (1) at Diameter relay node **106**, using PRT **114**; and (2) at Diameter relay node **112**, using PRT **120**. Significant

overhead is associated with Diameter routing lookups and can result in limited throughput, transaction per second rates, and scalability.

Figures 1 and 2 are not admitted prior art. Rather, Figures 1 and 2 illustrate one way in which Diameter routing could be performed and the disadvantages in performing Diameter routing in this manner.

Figure 3 is a network diagram illustrating an exemplary network that includes a DSR which includes multiple Diameter MPs that utilize common routing information stored at each MP to route Diameter messages according to an embodiment of the subject matter described herein. Referring to Figure 3, network **300** may include Diameter peer node "A" **302** and Diameter peer node "B" **304**. Network **300** may further include DSR **306**.

DSR **306** may be any suitable entity for routing or relaying Diameter signaling messages between Diameter nodes. For example, DSR **306** may be a long term evolution (LTE) signaling router, an LTE Diameter signaling router, a Diameter signaling agent, a Diameter proxy agent, a Diameter relay agent, a Diameter routing agent, a Diameter translation agent, or a Diameter redirect agent. DSR **306** may include functionality for processing various messages. In one embodiment, DSR **306** may communicate with various Diameter nodes via one or more 3rd generation partnership project (3GPP) LTE communications interfaces. In another embodiment, DSR **306** may communicate with various Diameter nodes via one or more other (e.g., non-LTE) communications interfaces. For example, DSR **306** may communicate with Internet protocol (IP) multimedia subsystem (IMS) nodes, such as call session control functions (CSCFs), using IMS-related interfaces.

A DSR may include multiple Diameter MPs. For example, DSR **306** includes Diameter MPs **308**, **310**, **312**, and **314**. A Diameter MP may be configured to host one or more Diameter applications. A Diameter MP may be a distinct message processing module of a distributed computing platform, a computing blade in a blade-based distributed computing platform, a processing core element associated with a single or multi-core computing device, or a virtual node instantiated on a single physical message

processing/computing device. A Diameter MP may utilize the Diameter protocol to route Diameter messages to external Diameter peer nodes.

DSR **306** may include multiple distinct message processing modules of a distributed computing platform, multiple computing blades in a blade-based distributed computing platform, multiple processing core elements associated with single or multi-core computing devices, or multiple virtual nodes instantiated on single physical message processing/computing devices. As such, an embodiment of DSR **306** may be located in a single distinct geographic location and communicate via an internal communications network. In an alternate embodiment, DSR **306** may include multiple elements located in geographically diverse locations and communicating via an external communications network.

Diameter MPs may be associated with a single Diameter identity. For example, Diameter MP **308** and Diameter MP **314** may be associated with a single Diameter identity "X" and appear as a single Diameter entity having Diameter identity "X," both from the perspective of Diameter peer node "A" **302** and the perspective of Diameter peer node "B" **304**. In such an embodiment, DSR **306** may also appear as a single Diameter entity having Diameter identity "X," both from the perspective of Diameter peer node "A" **302** and the perspective of Diameter peer node "B" **304**. In another embodiment, Diameter MPs may be associated with different Diameter identities. For example, Diameter MP **308** may be associated with Diameter identity "X" and Diameter MP **314** may be associated with Diameter identity "Y." In such an embodiment, Diameter MPs **308** and **314** may appear as single Diameter entities, respectively having Diameter identities "X" and "Y," while DSR **306** may appear as a single Diameter entity having multiple Diameter identities. For example, from the perspective of Diameter peer node "A" **302**, DSR **306** may have Diameter identity "X," while from the perspective of Diameter peer node "B" **304**, DSR **306** may have Diameter identity "Y."

In one embodiment, Diameter MPs may utilize copies of the same routing information stored at each Diameter MP. For example, Diameter MPs **308**, **310**, **312**, and **314** may respectively utilize copies of the same

routing information stored in PRTs and/or RLTs **316**, **318**, **320**, and **322**. In accordance with an embodiment of the subject matter described herein, Diameter MPs may use PRTs and/or RLTs for inter-MP routing. For example, Diameter MP **308** may utilize PRT/RLT **316** to route a Diameter message received from Diameter peer node "A" **302** and destined for Diameter peer node "B" **304** to egress Diameter MP **314**, as identified by PRT/RLT **316**. Moreover, because PRT/RLT **316** further identifies next-hop Diameter peer node "B" **304**, and an egress connection ID "Conn_12" existing between Diameter MP **314** and Diameter peer node "B" **304**, a subsequent Diameter lookup at Diameter MP **314** may not be required. In another embodiment, Diameter MPs may utilize common routing information stored in a shared repository.

Figure 4 is a network diagram illustrating an exemplary network that includes a DSR which includes multiple MPs that utilize common routing information stored in a shared repository to route Diameter messages according to an embodiment of the subject matter described herein. Elements **400**, **402**, **404**, **406**, **408**, **410**, **412**, and **414** are essentially identical to their respective counterparts **300**, **302**, **304**, **306**, **308**, **310**, **312**, and **314** in Figure 3, and therefore their descriptions will not be repeated here. Referring to Figure 4, Diameter MPs may utilize common routing information stored in a shared PRT and/or a shared RLT. For example, Diameter MPs **408**, **410**, **412**, and **414** may utilize common routing information stored in PRT/RLT table **416**. As in the above example, Diameter MP **408** may utilize PRT/RLT **416** to route a Diameter message received from Diameter peer node "A" **402** and destined for Diameter peer node "B" **404** to egress Diameter MP **414**, as identified by PRT/RLT **416**. Moreover, because PRT/RLT **416** further identifies next-hop Diameter peer node "B" **404** and an egress connection ID "Conn_12" existing between Diameter MP **414** and Diameter peer node "B" **404**, a subsequent Diameter lookup at Diameter MP **414** may not be required.

Figure 5 is a network diagram illustrating in more detail exemplary MPs for routing Diameter messages according to an embodiment of the subject matter described herein. Referring to Figure 5, Diameter peer node

"A" **402** may communicate with Diameter MP **408** via a Diameter protocol connection **500** that utilizes Diameter protocol/stack routing module **502** and Diameter peer node "B" **404** may communicate with Diameter MP **414** via a Diameter protocol connection **504** that utilizes Diameter protocol/stack routing module **506**. In accordance with an embodiment of the subject matter described herein, Diameter MPs may communicate within the DSR via a non-Diameter protocol connection. For example, Diameter MPs **408** and **414** may respectively utilize non-Diameter protocol stack/routing modules **510** and **512** to communicate via non-Diameter protocol connection **508**.

In accordance with an embodiment of the subject matter described herein, Diameter MPs may route a Diameter message between themselves using a non-Diameter protocol. Routing a Diameter message using a non-Diameter protocol may be advantageous by reducing the overhead required for a connection, for example, connection **508** between Diameter MPs **408** and **414**. In addition, routing a Diameter message using a non-Diameter protocol may reduce the number of Diameter stack/routing lookups required for a Diameter message to pass from Diameter peer node "A" **402** to Diameter peer node "B" **404**. For example, Diameter protocol stack/routing module **502** may be utilized for a Diameter message received by Diameter MP **408** from Diameter peer node "A" **402** and destined for Diameter peer node "B" **404**. Diameter stack/routing module **502** may identify next-hop Diameter peer node "B" **404** and may further identify a non-Diameter protocol route for the message to travel through DSR **406**. Diameter MPs **408** and **414** may utilize non-Diameter protocol stack routing modules **510** and **512** to route the message from Diameter MP **408** to Diameter MP **414** over non-Diameter protocol connection **508**. Moreover, because Diameter protocol stack/routing module **502** has already identified Diameter peer node "B" **404** and a non-Diameter protocol route for the message to travel through DSR **406**, non-Diameter protocol stack/routing module **506** may be utilized by Diameter MP **414** to route the message to Diameter peer node "B" **404**, thereby reducing the overall number of Diameter lookups.

Routing Diameter messages using a non-Diameter protocol may enable Diameter peer nodes **402** and **404** to communicate in accordance with the Diameter protocol via DSR **406**, while simultaneously facilitating communication within DSR **406** without the overhead associated with the establishment of a Diameter connection.

Non-Diameter protocol stack/routing module **510**, may insert a Diameter message processor identifier and a Diameter connection identifier in a received message or add the identifiers to the message before sending the message to Diameter message processor **414**. Non-Diameter protocol stack/routing module **512** may receive the message, examine the message processor identifier and the connection identifier, determine that an outbound Diameter route lookup is not required and that the message should be forwarded to next-hop Diameter node **414** via the connection identified in the message. In one embodiment, the non-Diameter protocol utilized may include an inter-processor message format that includes the original Diameter PDU along with a tag used for inter-MP routing. Figure 6 is a network diagram illustrating an exemplary inter-MP message for routing Diameter messages using a non-Diameter protocol according to an embodiment of the subject matter described herein. Referring to Figure 6, DSR **406** may include Diameter MPs **408** and **414**. In accordance with an embodiment of the subject matter described herein, Diameter MP **408** may receive a Diameter message **600** from an external Diameter peer node. Diameter MP **408** may utilize routing information stored in PRT **416** to determine that the Diameter message is destined for a Diameter peer node having a Diameter connection with Diameter MP **414**. Diameter MP **408** may create a non-Diameter protocol message **602** that contains at least a portion **604** of Diameter message **600**. In one embodiment, non-Diameter protocol message **602** may encapsulate Diameter message **600**. Non-Diameter protocol message **602** may include inter-MP routing tag **606**. Inter-MP routing tag **606** may include, for example, the identity/address of a Diameter MP having a Diameter connection with the next-hop Diameter peer node and/or information identifying the Diameter connection between the Diameter MP and the next-hop Diameter peer node for the message. In the

illustrated example, non-Diameter protocol message **602** includes inter-MP routing tag **606** which identifies Diameter MP **414** and connection **608** between Diameter MP **414** and a next-hop Diameter peer node.

In accordance with an embodiment of the subject matter described herein, Diameter MP **408** may route non-Diameter protocol message **602** to another Diameter MP. For example, Diameter MP **408** may route non-Diameter protocol message **602** to Diameter MP **414**. Diameter MP **408** may insert or add inter-MP routing tag **606** to Diameter message **600** or message portion **604** prior to forwarding the message to Diameter MP **414**. In one embodiment, Diameter MP **414** may determine that non-Diameter protocol message **602** is from a Diameter MP within DSR **406**. For example, Diameter MP **414** may determine that non-Diameter protocol message **602** is from a Diameter MP within DSR **406** by detecting the existence of inter-MP routing tag **606**, or Diameter MP **414** may determine that non-Diameter protocol message **602** is from a Diameter MP within DSR **406** based on the interface on which non-Diameter protocol message **602** is received. Diameter MP **414** may utilize inter-MP routing tag **606** to route the original Diameter message **600** or a portion thereof to an external Diameter peer node. For example, Diameter MP **414** may create a second Diameter message **610**. Diameter message **610** may contain at least a portion **604** of Diameter message **600**. Diameter MP **414** may forward Diameter message **610** to an external Diameter peer node via connection **608**.

Figure 7 is a message flow diagram illustrating the routing of a Diameter message according to an embodiment of the subject matter described herein. Referring to Figure 7, at step 1, Diameter peer node "A" **402** may send to Diameter peer node "B" **404** a request message according to the Diameter protocol. DSR **406**, which includes Diameter MP **408** and Diameter MP **414**, may serve a communication path existing between Diameter peer node "A" **402** and Diameter peer node "B" **404**. Diameter MP **408** may receive the Diameter request message from Diameter peer node A **402** and create a non-Diameter protocol message that includes at least a part of the received Diameter request message. At step 2, Diameter MP **408** may route the non-Diameter protocol message that it created to Diameter

MP **414**. Diameter MP **414** may create a second Diameter message that includes the at least a portion of the first Diameter message. At step 3, Diameter MP **414** may forward the second Diameter message to Diameter peer node "B" **404**.

Figures 8 and 9 illustrate exemplary data that may be stored in a peer routing table and associate route list table that may be used by Diameter message processors within a DSR for routing Diameter signaling messages between message processors according to an embodiment of the subject matter described herein. Referring to Figure 8, peer routing table **800** includes a variety of fields that are used to route Diameter signaling messages. For example, a lookup may be performed at an ingress message processor based on a combination of destination host, destination realm, application identifier, originating host, and an originating realm parameter stored in the message. It should be noted that some or all of these parameters may be used in performing the route lookup. If the result of the lookup in the route table matches one of the entries, the action field in the route table is used to determine the action to be performed for the message. The route list field in the peer routing table is used to determine a route list identifier, which is used to perform a lookup in the route list table. Referring to Figure 9, route list table **900** includes entries that are accessible via route list identifiers, which are determined from the peer routing table. The route list identifier determined from the peer routing table may match multiple entries in route list table **900**. The priority, weight, and route status may be used to identify the route that a particular message will take. For example, if the route list determined for a message is "BLUE_NW," the selected route name may be "BLUE_PEER1," "BLUE_PEER2," or "BLUE_PEER3," depending on the priority of the message, the status of the route, and the weight assigned to the particular route.

The egress message processor identifier field contains data that is used to create the inter-MP status tag that is added to the message before sending the message to the egress message processor. The egress connection identifier field in the table is also added to the inter-MP routing

tag and is used by the egress message processor to identify the egress Diameter connection.

Figure 10 illustrates a table listing advantages associated with routing Diameter messages according to an embodiment of the subject matter described herein. Referring to Figure 10, table **1000** graphically compares and contrasts the use of Diameter and non-Diameter message processor (MP)-to-MP protocols. Both Diameter and non-Diameter MP-to-MP protocols are Ethernet/IP based. While both Diameter and non-Diameter MP-to-MP protocols are reliable and connection oriented, utilizing non-Diameter MP-to-MP protocol is not limited to stream control transmission protocol (SCTP) or transmission control protocol (TCP). Diameter protocol provides security via standards-based security protocols such as Internet protocol security (IPSEC) and transport layer security (TLS) which are associated with high overhead. In contrast, non-Diameter MP-to-MP protocol security is provided via a closed/private network and is associated with low overhead. Diameter protocol message content is limited to Diameter standard protocol data unit (PDU) format. In contrast, non-Diameter MP-to-MP protocol may include Diameter standard PDU and may further include additional proprietary fields for minimizing processing overhead over the full ingress-egress path, handling error conditions, and managing in-service upgrades. Diameter protocol employs a routing strategy that utilizes Diameter routing at each MP which is associated with high overhead and relies primarily on static routing rules which results in perpetual message bouncing when egress paths are unavailable. In contrast, non-Diameter MP-to-MP protocol employs a routing strategy in which routing is optimized to minimize overhead across the full ingress-to-egress path using proprietary message content (e.g., by obviating the necessity for the egress node to perform another Diameter route lookup) and complements static routing rules with proprietary inter-MP status sharing to choose "available" egress paths.

Figure 11 is a flow chart illustrating an exemplary process for routing Diameter messages according to an embodiment of the subject matter described herein. Referring to Figure 11, in step **1100**, a first Diameter MP

receives a Diameter message from a first Diameter node via a first Diameter connection. For example, an ingress message processor within a DSR may receive a message over a Diameter connection from a Diameter peer of the ingress message processor. In step **1102**, the first Diameter MP determines a next-hop Diameter node for the Diameter message. For example, the first Diameter message processor may perform a lookup in a shared or non-shared peer routing table to determine the next-hop external Diameter node as well as the Diameter message processor within the DSR used to reach the next-hop Diameter node. In step **1104**, the first Diameter MP communicates the Diameter message to a second Diameter MP. For example, the first MP may add the inter-MP status tag to the first Diameter message and forward the message with the tag to the egress Diameter MP. In step **1106**, the second Diameter MP communicates the Diameter message to the next-hop Diameter node via a second Diameter connection. For example, the second Diameter MP may use information in the inter-MP status tag to identify the message as being directed to the egress MP, as not requiring another route lookup, and to identify the outbound Diameter connection to the peer.

Figure 12 is a network diagram illustrating an exemplary network that includes a DSR which appears to have different Diameter identities from the perspective of different Diameter peer nodes for routing Diameter messages according to an embodiment of the subject matter described herein. Referring to Figure 12, network **1200** may include Diameter peer node "A" **1202** and Diameter peer node "B" **1204**. Network **1200** may further include DSR **1206**. In accordance with an embodiment of the subject matter described herein, DSR **1206** may appear to a first Diameter peer node as a first Diameter node having a first Diameter identity and appear to a second Diameter peer node as a second Diameter node having a second Diameter identity different from the first Diameter identity. For example, DSR **1206** may appear to Diameter peer node "A" **1202** as a first Diameter node having Diameter identity "X" and appear to Diameter peer node "B" **1204** as a second Diameter node having Diameter identity "Y."

It will be understood that various details of the subject matter described herein may be changed without departing from the scope of the subject matter described herein. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation, as the subject matter described herein is defined by the claims as set forth hereinafter.

CLAIMS

What is claimed is:

1. A method for routing Diameter messages, the method comprising:

at a Diameter signaling router (DSR) comprising a plurality of Diameter message processors:

receiving, by a first of the plurality of Diameter message processors and from a first Diameter node, a Diameter message, wherein the Diameter message is received via a first Diameter connection;

determining, by the first Diameter message processor, a next-hop Diameter node for the Diameter message;

communicating, by the first Diameter message processor and to a second of the plurality of Diameter message processors, the Diameter message; and

communicating, by the second Diameter message processor and to the next-hop Diameter node, the Diameter message, wherein the Diameter message is communicated via a second Diameter connection.

2. The method of claim 1 wherein the second Diameter message processor is configured to communicate the Diameter message based on the determination made by the first Diameter message processor.

3. The method of claim 1 wherein the first Diameter node and the next-hop Diameter node are peers of the first and second Diameter message processors, respectively, and are respectively connected to the first and next-hop Diameter nodes using the first and second Diameter connections.

4. The method of claim 1 wherein the first and second Diameter message processors are not connected to each other via a Diameter connection.

5. The method of claim 1 wherein the first and second Diameter message processors share or access a common Diameter peer routing table.

6. The method of claim 1 each of the first and second Diameter message processors includes a peer routing table.

7. The method of claim 1 wherein the first Diameter message processor appears to the first Diameter node having a first Diameter identity and the second Diameter message processor appears to the next-hop Diameter node as having a second Diameter identity, the first and second Diameter identities being different from each other.

8. The method of claim 1 wherein the first and second Diameter message processors appear to the first Diameter node and the next-hop Diameter node as a single Diameter node having a single Diameter identity, the single Diameter identity being associated with the DSR.

9. The method of claim 1 wherein at least one of the first and second of the plurality of Diameter message processors comprises one of:

a distinct message processing module of a distributed computing platform;

a computing blade in a blade-based distributed computing platform;

a processing core element associated with a single or multi-core computing device; and

a virtual node instantiated on a single physical message processing / computing device.

10. The method of claim 1 wherein the first Diameter message processor adds an inter-message processor routing tag identifier to the Diameter message before sending the message to the second Diameter message processor and wherein the second Diameter message processor uses the inter-message processor routing tag to identify the message as being directed to it and as not requiring another Diameter routing lookup.

11. A system for routing Diameter messages, the system comprising:

a Diameter signaling router (DSR) including:

first and second Diameter message processors, wherein the first Diameter message processor is configured to:

receive, from a first Diameter node and via a first Diameter connection, a Diameter message;

determine a next-hop Diameter node for the Diameter message; and

communicate, to the second Diameter message processor, the Diameter message, and wherein the second Diameter message processor is configured to communicate to the next-hop Diameter node, via a second Diameter connection, the Diameter message.

12. The system of claim 11 wherein the second Diameter message processor is configured to communicate the Diameter message based on the determination made by the first Diameter message processor.

13. The system of claim 11 wherein the first Diameter node and the next-hop Diameter node are peers of the first and second Diameter message processors, respectively, and are respectively connected to the first and next-hop Diameter nodes using the first and second Diameter connections.

14. The system of claim 11 wherein the first and second Diameter message processors are not connected to each other via a Diameter connection.

15. The system of claim 11 wherein the first and second Diameter message processors share or access a common Diameter peer routing table.

16. The system of claim 11 wherein each of the first and second Diameter message processors includes a peer routing table.

17. The system of claim 11 wherein the first Diameter message processor appears to the first Diameter node as having a first Diameter identity and the second Diameter message processor appears to the next-hop Diameter node as having a second Diameter identity, the first and second Diameter identities being different from each other.

18. The system of claim 11 wherein the first and second Diameter message processors appear to the first Diameter node and the next-hop Diameter node as a single Diameter node having a single

Diameter identity, the single Diameter identity being associated with the DSR.

19. The system of claim 11 wherein at least one of the first and second Diameter message processors comprises one of:

a distinct message processing module of a distributed computing platform;

a computing blade in a blade-based distributed computing platform;

a processor core element associated with a single or multi-core computing device; and

a virtual node instantiated on a single physical message processing / computing device.

20. The system of claim 11 wherein the first Diameter message processor adds an inter-message processor routing tag identifier to the Diameter message before sending the message to the second Diameter message processor and wherein the second Diameter message processor uses the inter-message processor routing tag to identify the message as being directed to it and as not requiring another Diameter routing lookup.

21. A system for routing Diameter messages, the system comprising:

a first Diameter node;

a second Diameter node; and

a Diameter signaling router (DSR), wherein the DSR appears to the first Diameter node as a first Diameter peer having a first Diameter identity and the DSR appears to the second Diameter node as a second Diameter peer having a second Diameter identity, the second Diameter identity and the first Diameter identity being different.

22. A non-transitory computer readable medium comprising computer executable instructions that when executed by a processor of a computer control the computer to perform steps comprising:

at a Diameter signaling router (DSR) comprising a plurality of Diameter message processors:

receiving, by a first of the plurality of Diameter message processors and from a first Diameter node, a Diameter message, wherein the Diameter message is received via a first Diameter connection;

determining, by the first Diameter message processor, a next-hop Diameter node for the Diameter message;

communicating, by the first Diameter message processor and to a second of the plurality of Diameter message processors, the Diameter message; and

communicating, by the second Diameter message processor and to the next-hop Diameter node, the Diameter message, wherein the Diameter message is communicated via a second Diameter connection.

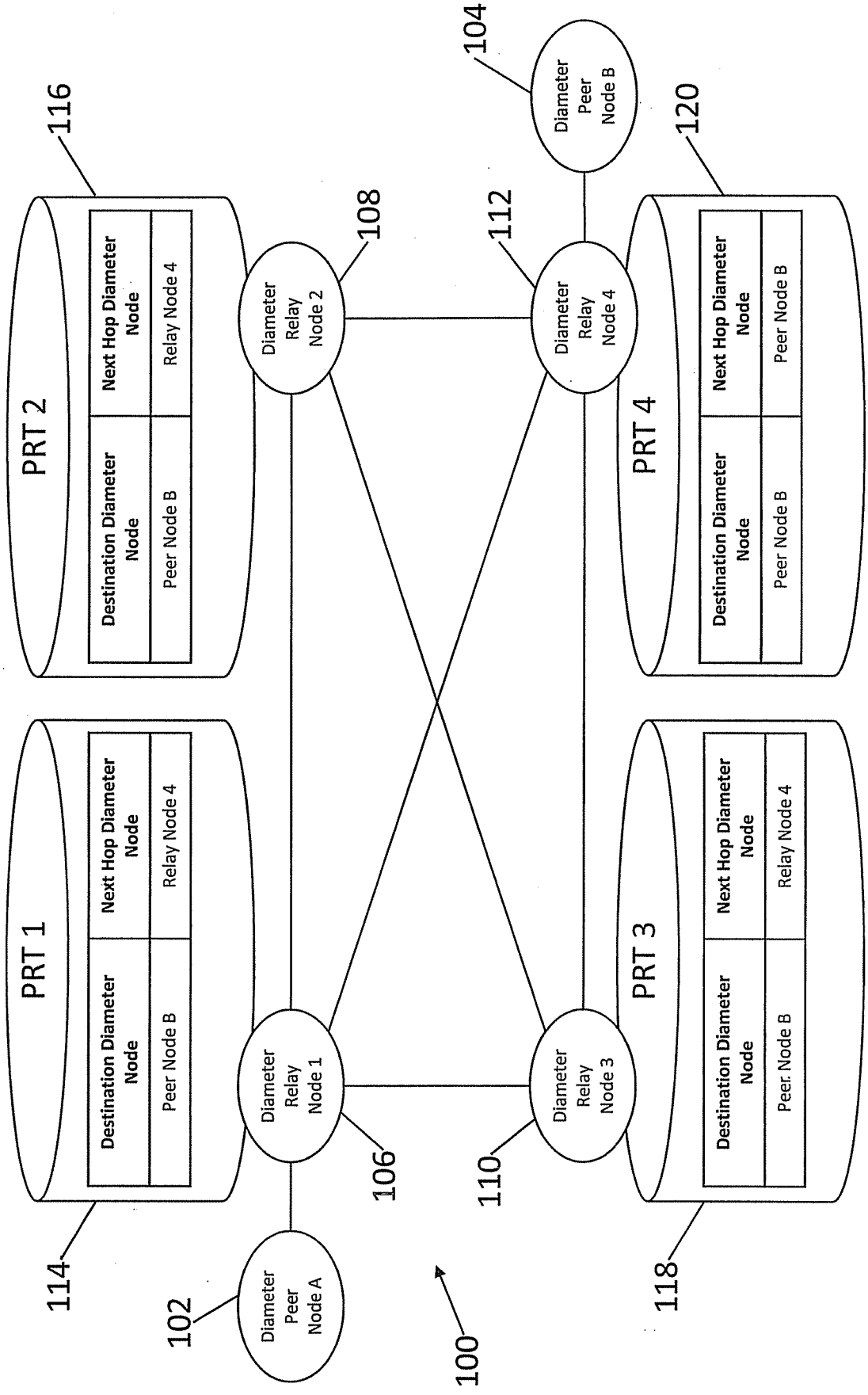

PRT 1
Destination Diameter Node
Next Hop Diameter Node
Peer Node B
Relay Node 4
PRT 2
Destination Diameter Node
Next Hop Diameter Node
Peer Node B
Relay Node 4
PRT 3
Destination Diameter Node
Next Hop Diameter Node
Peer. Node B
Relay Node 4
PRT 4
Destination Diameter Node
Next Hop Diameter Node
Peer Node B
Peer Node B
Diameter Peer Node A
Diameter Peer Node B
Diameter Relay Node 1
Diameter Relay Node 2
Diameter Relay Node 3
Diameter Relay Node 4
100
102
104
106
108
110
112
114
116
118
120

FIG. 1

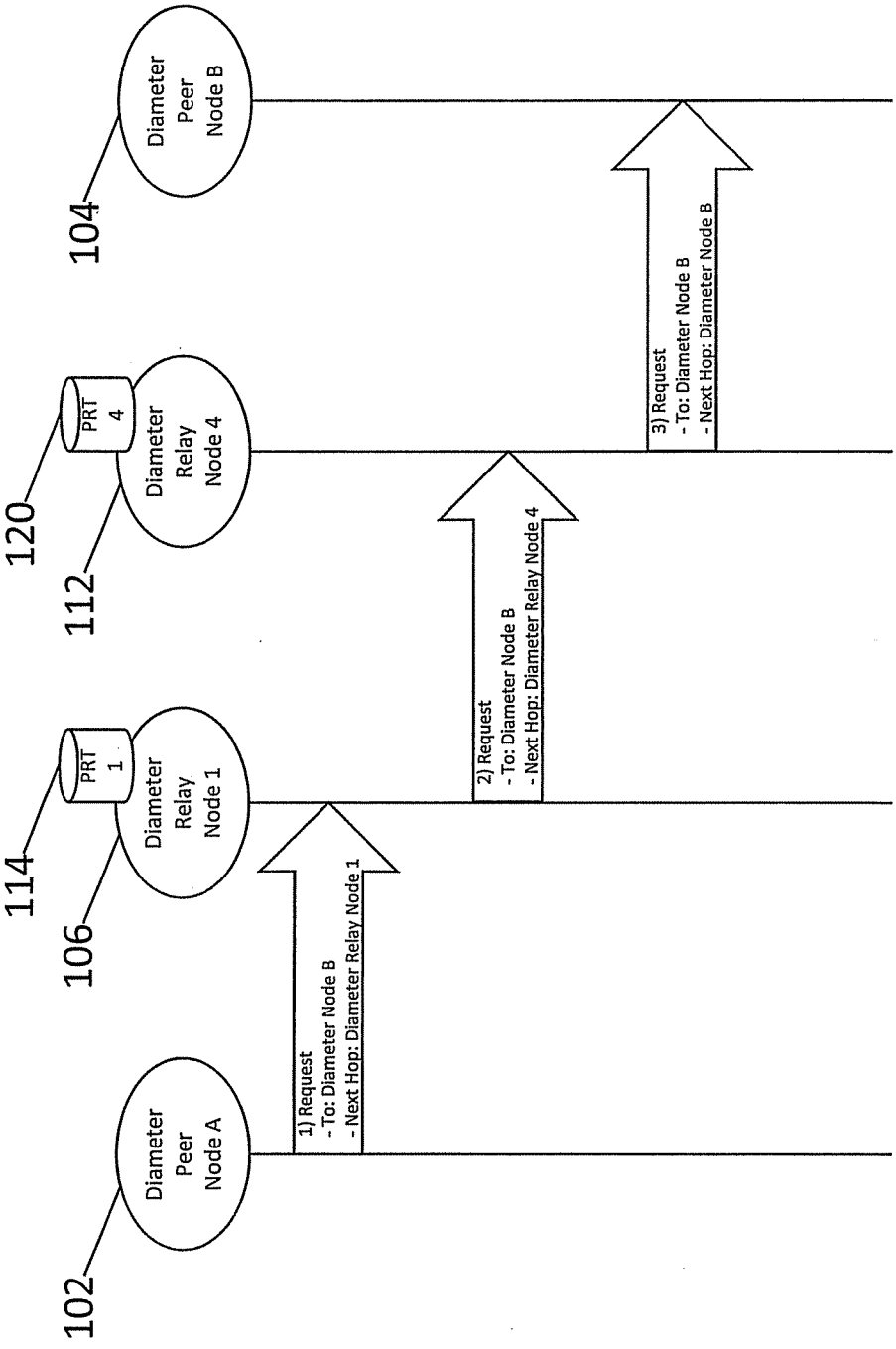

Diameter Peer Node A
102
Diameter Relay Node 1
106
PRT 1
114
Diameter Relay Node 4
112
PRT 4
120
Diameter Peer Node B
104
1) Request
- To: Diameter Node B
- Next Hop: Diameter Relay Node 1
2) Request
- To: Diameter Node B
- Next Hop: Diameter Relay Node 4
3) Request
- To: Diameter Node B
- Next Hop: Diameter Node B

FIG. 2

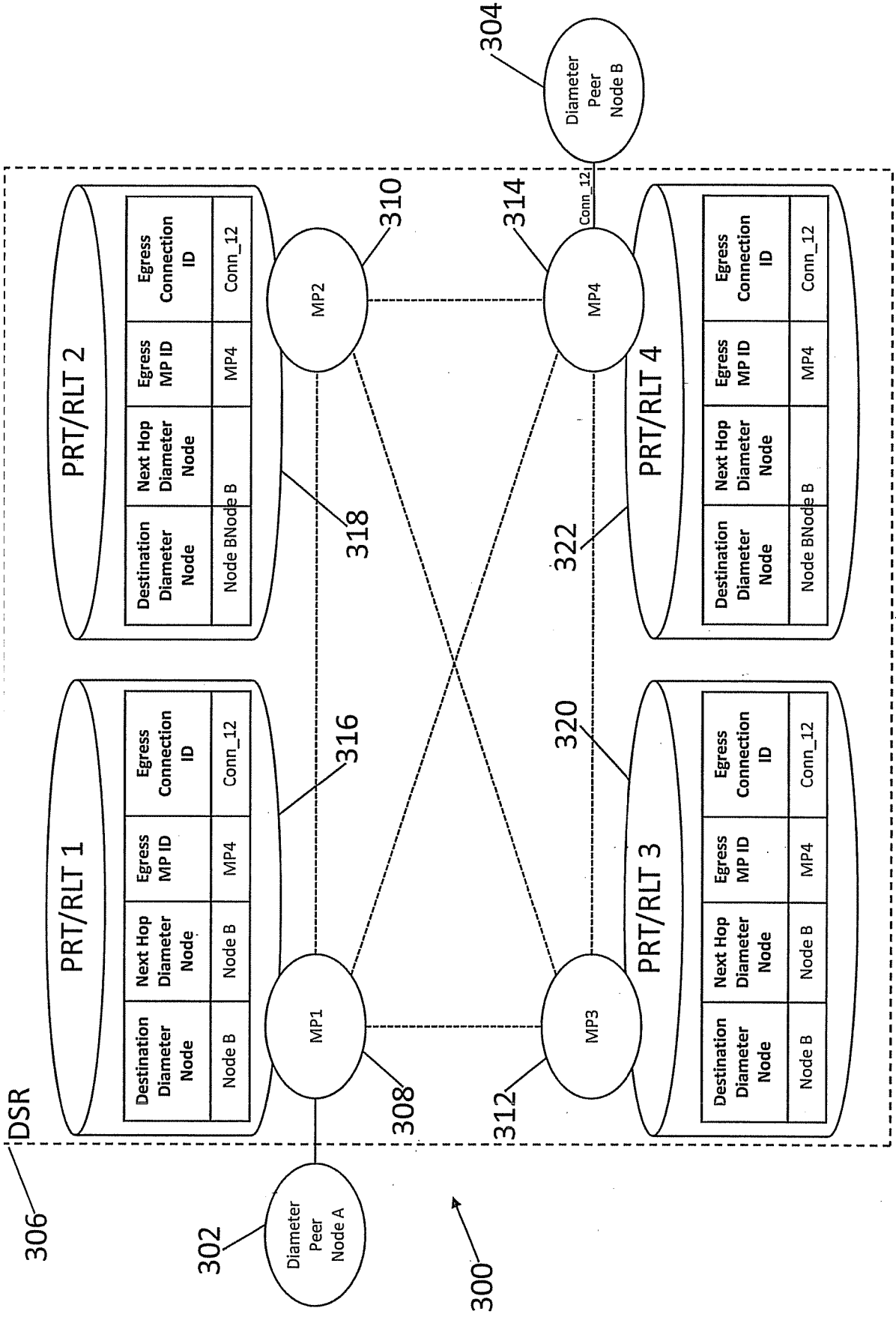

DSR
306
302
Diameter Peer Node A
300
304
Diameter Peer Node B
Conn_12
MP1
MP2
MP3
MP4
308
310
312
314
316
318
320
322
PRT/RLT 1
PRT/RLT 2
PRT/RLT 3
PRT/RLT 4
Destination Diameter Node
Next Hop Diameter Node
Egress MP ID
Egress Connection ID
Node B
Node BNode B
MP4
Conn_12

FIG. 3

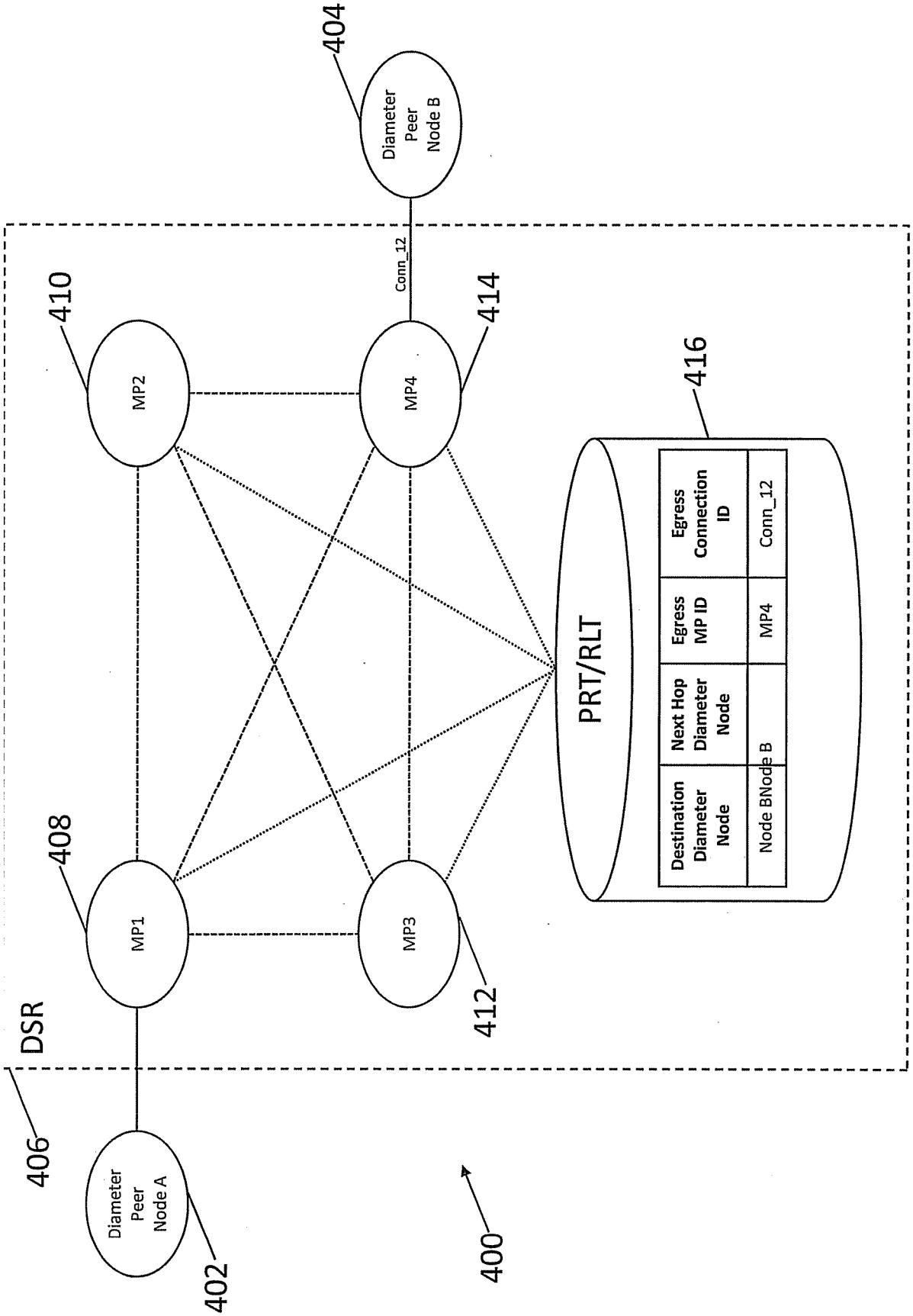

400
402
Diameter Peer Node A
406
DSR
408
MP1
410
MP2
412
MP3
414
MP4
404
Diameter Peer Node B
Conn_12
416
PRT/RLT
Destination Diameter Node
Next Hop Diameter Node
Egress MP ID
Egress Connection ID
Node BNode B
MP4
Conn_12

FIG. 4

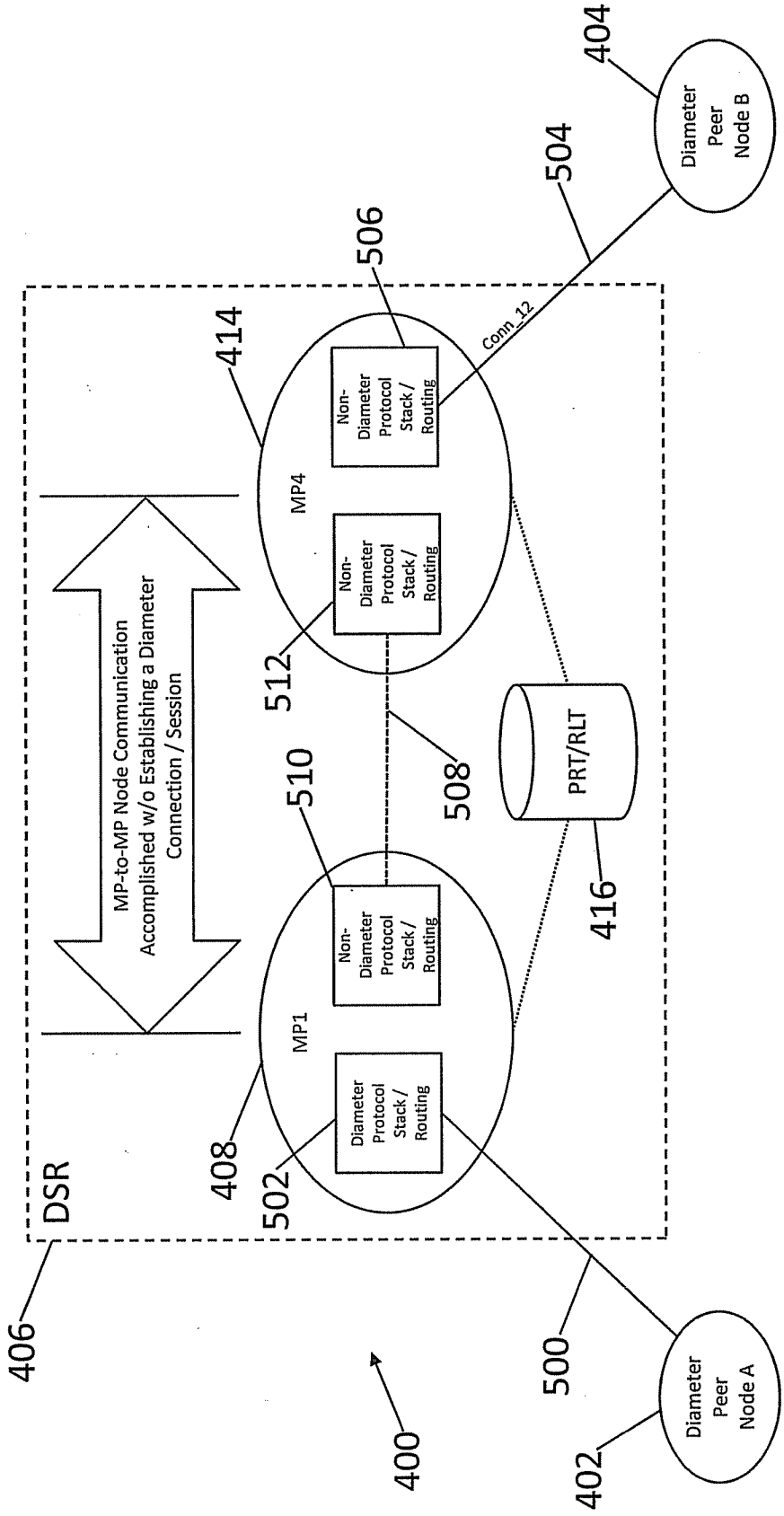

400
402
Diameter Peer Node A
404
Diameter Peer Node B
406
DSR
408
414
502
504
506
508
510
512
416
500
Conn_12
MP1
MP4
Diameter Protocol Stack / Routing
Non-Diameter Protocol Stack / Routing
PRT/RLT
MP-to-MP Node Communication Accomplished w/o Establishing a Diameter Connection / Session

FIG. 5

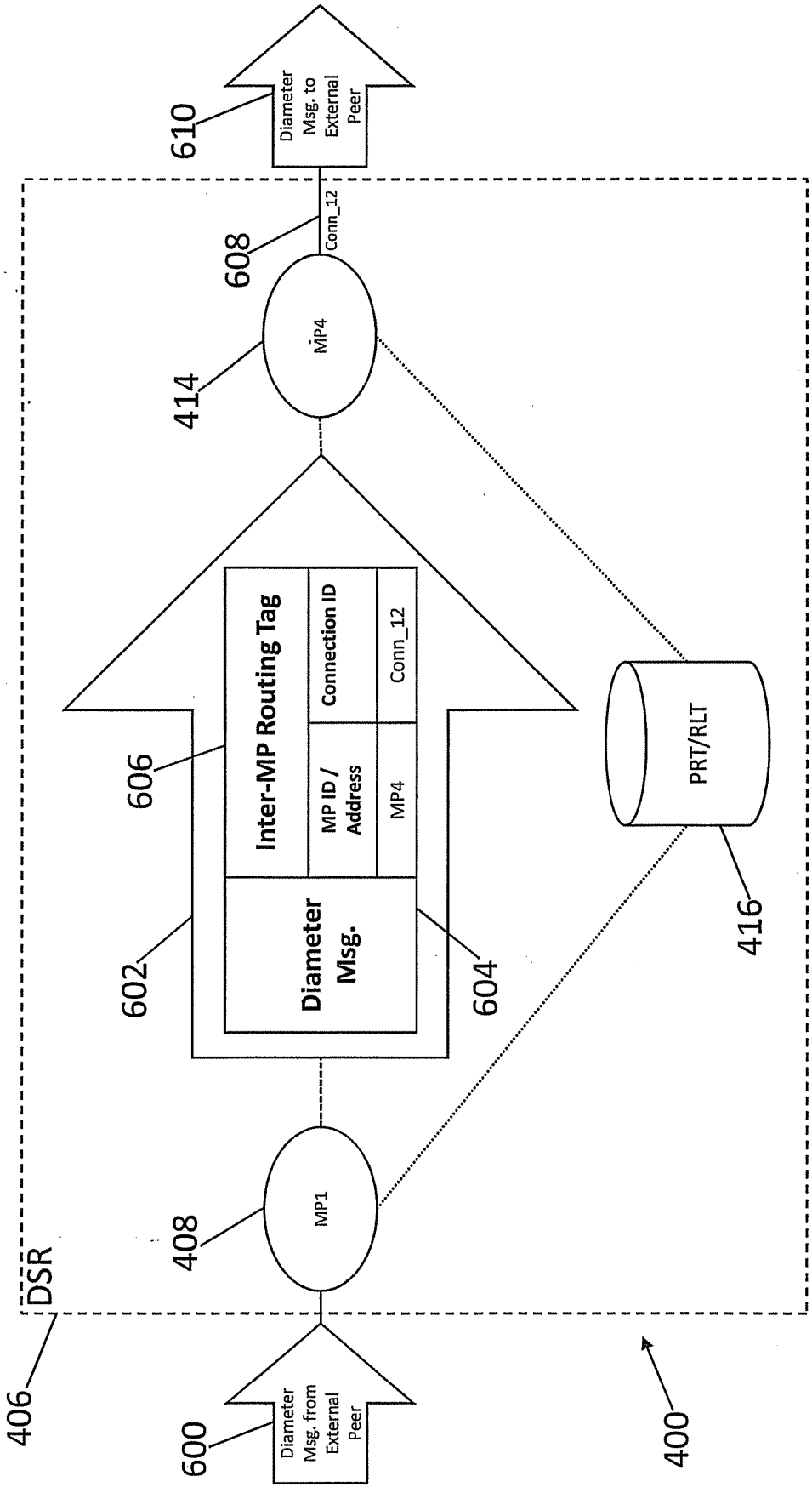

Diameter Msg. from External Peer
600
406
DSR
408
MP1
Diameter Msg.
Inter-MP Routing Tag
MP ID / Address
Connection ID
MP4
Conn_12
602
604
606
PRT/RLT
416
414
MP4
608
Conn_12
Diameter Msg. to External Peer
610
400

FIG. 6

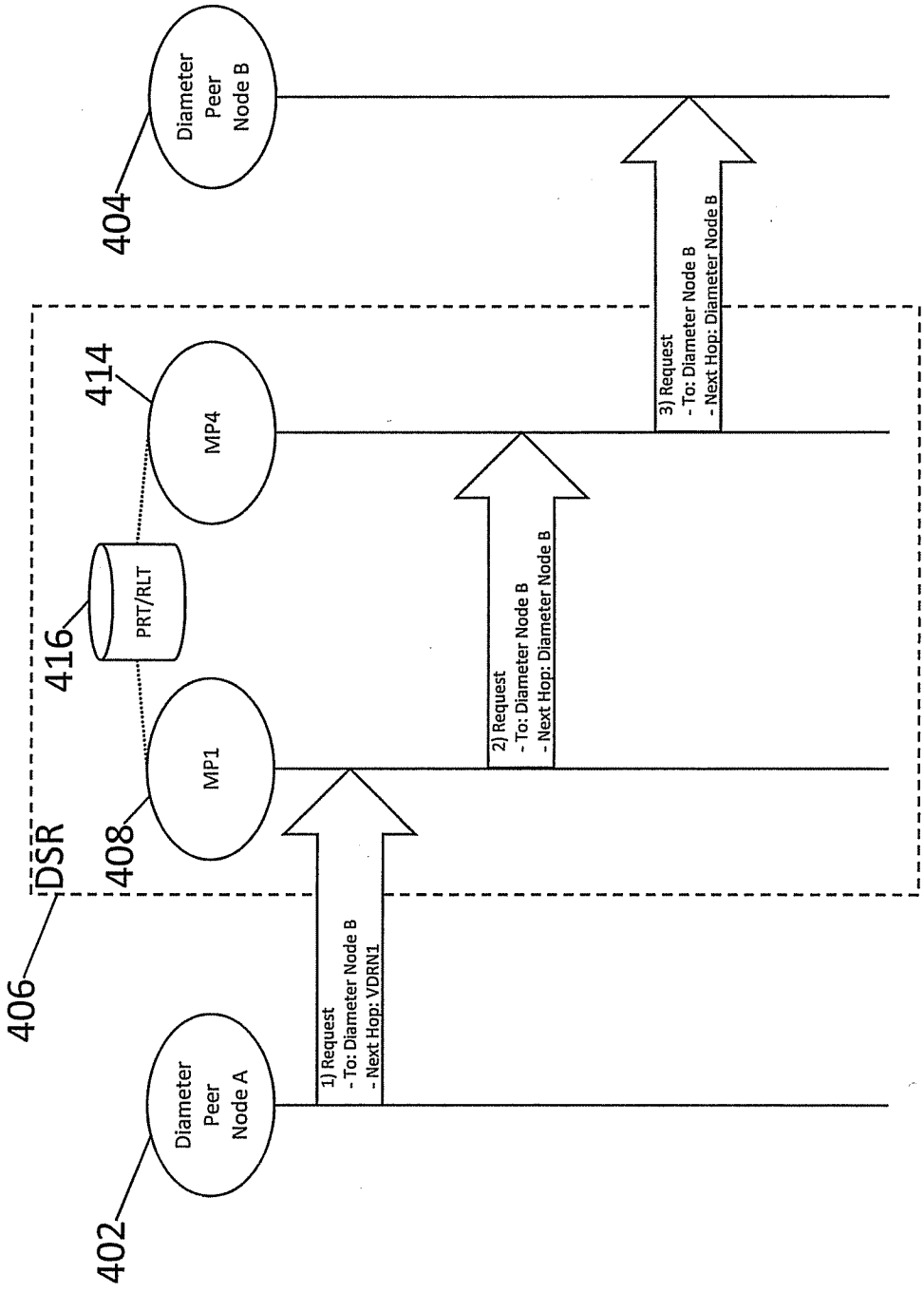

Diameter Peer Node B
404
414
MP4
PRT/RLT
416
MP1
408
DSR
406
Diameter Peer Node A
402
1) Request
- To: Diameter Node B
- Next Hop: VDRN1
2) Request
- To: Diameter Node B
- Next Hop: Diameter Node B
3) Request
- To: Diameter Node B
- Next Hop: Diameter Node B

FIG. 7

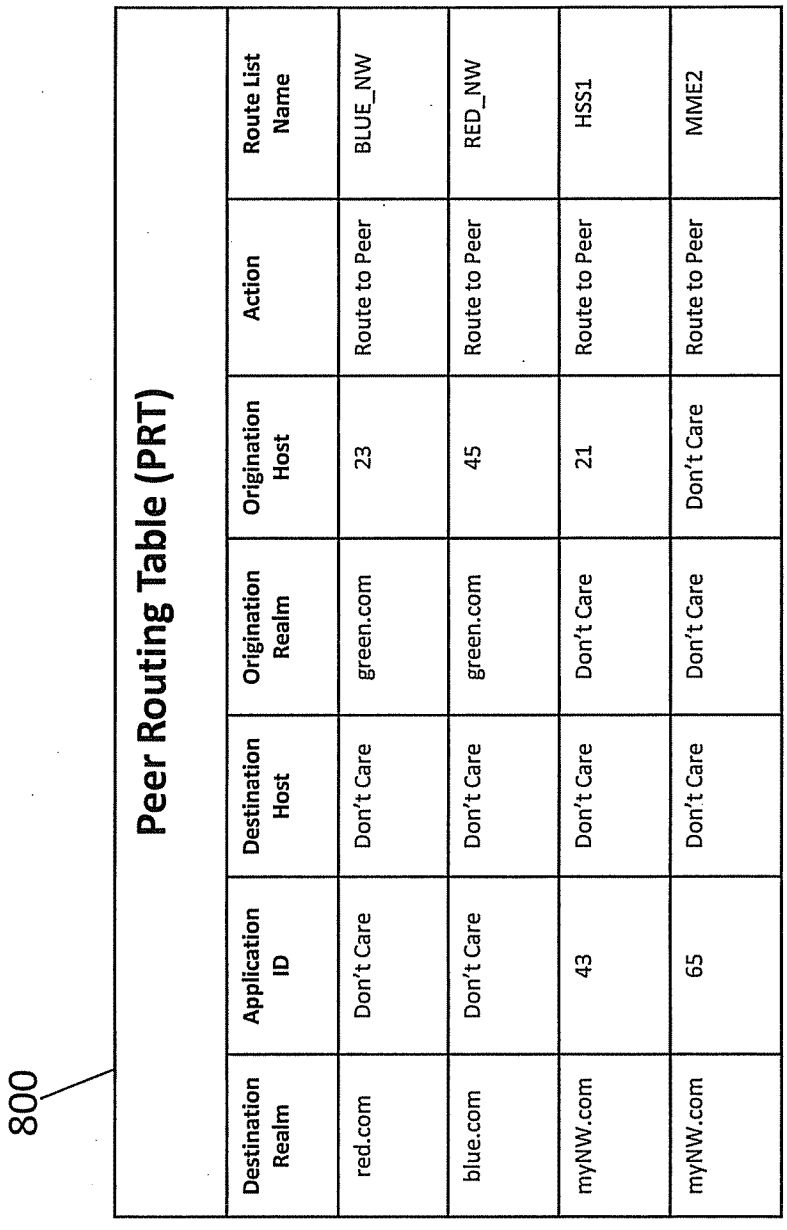

800
Peer Routing Table (PRT)
Destination Realm
Application ID
Destination Host
Origination Realm
Origination Host
Action
Route List Name
red.com
Don't Care
Don't Care
green.com
23
Route to Peer
BLUE_NW
blue.com
Don't Care
Don't Care
green.com
45
Route to Peer
RED_NW
myNW.com
43
Don't Care
Don't Care
21
Route to Peer
HSS1
myNW.com
65
Don't Care
Don't Care
Don't Care
Route to Peer
MME2

FIG. 8

900

Route List Table (RLT)						
Route List Name	**Route Name**	**Priority**	**Weight**	**Route Group**	**Egress Conn ID**	**Egress MP ID**
BLUE_NW	BLUE_PEER1	1	60	Active	Conn_12	MP4
BLUE_NW	BLUE_PEER2	1	40	Active	Conn_13	MP4
BLUE_NW	BLUE_PEER3	2	50	Standby	Conn_14	MP4
BLUE_NW	BLUE_PEER4	2	50	Standby	Conn_15	MP4
RED_NW	RED_PEER1	1	100	Active	Conn_16	MP5
RED_NW	RED_PEER2	2	100	Standby	Conn_17	MP5
HHS1	HSS1_SRV1	1	100	Active	Conn_18	MP6
MME1	MME1_SRV1	1	100	Active	Conn_19	MP6
MME1	MME1_SRV2	2	100	Standby	Conn_20	MP7

FIG. 9

1000

Diameter vs. Non-Diameter Protocol		
Transport Attribute	**Diameter**	**Non-Diameter Message Processor-to-Message Processor**
Ethernet/ Internet Protocol (IP) Based	Yes	Yes
Reliable, Connection Oriented	Yes, stream control transmission protocol (SCTP) or transmission control protocol (TCP) required	Yes, but not limited to SCTP or TCP
Security	Via standards-based security protocols such as Internet protocol security (IPSEC) and transport layer security (TLS) → High Overhead	Via closed/private network → No Overhead
Message Content	Diameter standard protocol data unit (PDU) format	Diameter standard PDU + additional proprietary fields for minimizing processing overhead over full ingress-egress path, handling error conditions, and managing in-service upgrades
Routing Strategy	• Diameter standard routing at each MP → High Overhead • Relies primarily on static routing rules → results in perpetual message bouncing when egress paths are unavailable	• Routing optimized to minimize overhead across full ingress-to-egress path using proprietary message content, e.g., by obviating the necessity for the egress message processor (MP) node to perform another Diameter route lookup • Complements static routing rules with proprietary inter-MP status sharing to choose "available" egress paths

FIG. 10

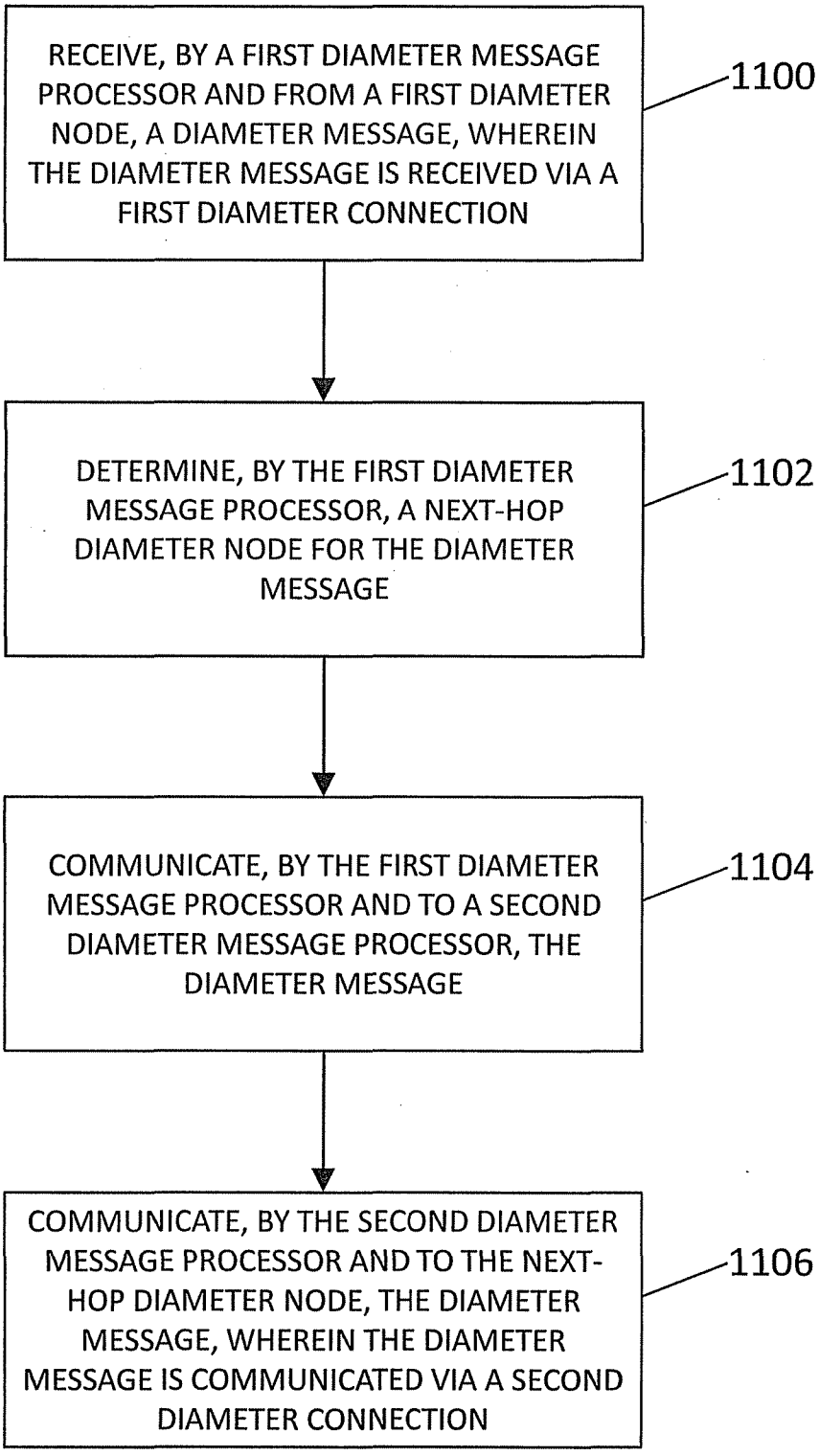

RECEIVE, BY A FIRST DIAMETER MESSAGE PROCESSOR AND FROM A FIRST DIAMETER NODE, A DIAMETER MESSAGE, WHEREIN THE DIAMETER MESSAGE IS RECEIVED VIA A FIRST DIAMETER CONNECTION
1100
DETERMINE, BY THE FIRST DIAMETER MESSAGE PROCESSOR, A NEXT-HOP DIAMETER NODE FOR THE DIAMETER MESSAGE
1102
COMMUNICATE, BY THE FIRST DIAMETER MESSAGE PROCESSOR AND TO A SECOND DIAMETER MESSAGE PROCESSOR, THE DIAMETER MESSAGE
1104
COMMUNICATE, BY THE SECOND DIAMETER MESSAGE PROCESSOR AND TO THE NEXT-HOP DIAMETER NODE, THE DIAMETER MESSAGE, WHEREIN THE DIAMETER MESSAGE IS COMMUNICATED VIA A SECOND DIAMETER CONNECTION
1106

FIG. 11

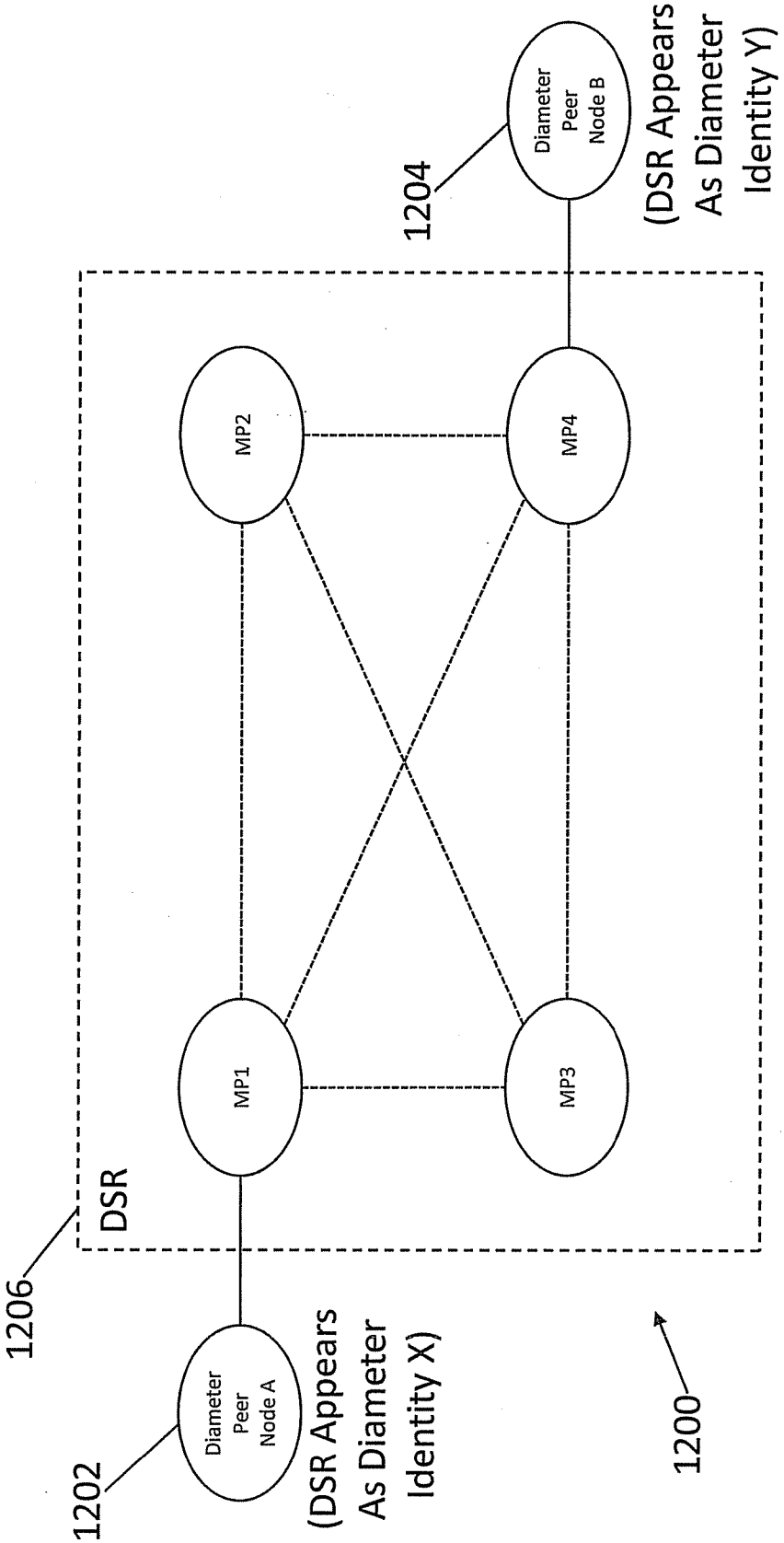

1206
DSR
MP1
MP2
MP3
MP4
1202
Diameter Peer Node A
(DSR Appears As Diameter Identity X)
1204
Diameter Peer Node B
(DSR Appears As Diameter Identity Y)
1200

FIG. 12