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(54) **SYSTEM FOR PROVIDING POLICY AND CHARGING RULES FUNCTION (PCRF) WITH INTEGRATED OPENFLOW CONTROLLER**

SYSTEM ZUR BEREITSTELLUNG VON RICHTLINIEN- UND LADUNGSREGELUNGSFUNKTIONEN MIT INTEGRIERTER OPENFLOW-STEUERUNG

SYSTÈME POUR FOURNIR UNE FONCTION DE RÈGLES DE POLITIQUE ET DE FACTURATION (PCRF) AYANT UN DISPOSITIF DE COMMANDE OPENFLOW INTÉGRÉ

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Description

TECHNICAL FIELD

[0001] The subject matter described herein relates to enabling flexible allocation of resources in telecommunications networks. More particularly, the subject matter described herein relates to a PCRF with an integrated openflow controller.

BACKGROUND

[0002] In telecommunications networks, global Internet protocol traffic is increasing at a rate of forty to fifty percent per year. In order to retain subscribers, it is desirable for service providers to keep monthly charges to subscribers relatively unchanged. Keeping charges constant with increasing traffic requires a reduction in expenses. For example, with a forty percent increase in traffic, service providers must reduce capital expenses and operational expenses by forty to fifty percent per gigabyte per second per year to achieve relatively constant pricing.

[0003] One possible method for reducing capital and operational expenses is to use software defined networks (SDNs). SDNs can be used to manage flows, control switches, control network access, and track user location and motion. SDNs can also be used to efficiently use network components. For example, SDNs may be used to power off unused equipment during non-peak periods to conserve energy.

[0004] Some SDN models centralize the control of network elements, such as routers and switches, by removing intelligence from the routers and switches and placing that intelligence in a centralized location. One such effort to provide centralized control of routers and switches is the openflow architecture described in the Openflow Switch Specification, Version 1.1.0, February 28, 2011, the disclosure of which is incorporated herein by reference in its entirety and a copy of which is attached hereto. According to the Openflow Switch Specification, an openflow controller controls functions of openflow-enabled switches. Openflow has not been used to control telecommunications network elements. Accordingly, there exists a need for extending openflow into telecommunications networks to reduce operating and capital expenses and to make networks more scalable and more flexible.

[0005] CellSDN: "Software-Defined Cellular Networks", Li Erran et al (30 April 2012) describes the advantages that software-defined networking (SDN) can provide for cellular networks. A software-defined cellular network architecture can allow controller applications to express policies based on the attributes of subscribers, rather than network addresses and locations. A SDN controller can run a collection of application modules including a policy and charging rule function that can influence traffic monitoring and packet scheduling.

[0006] WO 2012/160465, which is part of the state of the art under Article 54(3) EPC, describes a method for implementing a control plane of an evolved packet core of a 3GPP LTE network in a cloud computing system. This document describes an Openflow Switch with a plurality of flow tables. A packet received at the switch can be compared against each of the flow tables to accumulate actions into an action set.

SUMMARY

[0007] The subject matter described herein includes methods, systems, and computer readable media for providing a PCRF with an integrated openflow controller. According to one system, a policy and charging rules function (PCRF) is configured to determine policies to apply to network sessions or users. An openflow controller is integrated with the PCRF and configured to provide instructions to telecommunications network elements in an openflow protocol to implement the policies.

[0008] 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 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

[0009] Preferred embodiments of 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 PCRF with an integrated openflow controller controlling telecommunications network elements according to an embodiment of the subject matter described herein;

Figure 2 is a block diagram illustrating an exemplary architecture for an SDN including an openflow-enabled PCRF according to an embodiment of the subject matter described herein; and

Figure 3 is a message flow diagram illustrating exemplary messaging for a PCRF to provide policy instructions to telecommunications network nodes via using an openflow protocol according to an embodiment of the subject matter described herein.

DETAILED DESCRIPTION

[0010] The subject matter described herein includes a PCRF with an integrated openflow controller. Figure 1 illustrates an example of such a PCRF. In Figure 1 PCRF **100** includes integrated openflow controller **102**. Openflow controller **102** implements the above-described openflow protocol to control one or more of eNode B **104**, BRAS/BNG **106**, GGSN or PDN-GW/S-GW **108**, a Wi-Fi access point (not shown) or one or more openflow switches or routers (not shown). In the illustrated example, PCRF **100** also includes a non-openflow interface **109** for controlling non-openflow devices, such as online charging system (OCS) **110** or deep packet inspection (DPI) node **112**. Non-openflow interface **109** may be a Diameter interface or other suitable interface for communicating with non-openflow nodes, such as OCS **110** and DPI **112**.

[0011] Conventionally, the network in Figure 1 operated by providing much of the routing intelligence in nodes **104**, **106**, and **108**. PCRF **100** conventionally controlled such nodes using only a layer 7 protocol, such as Diameter. In the illustrated embodiment, PCRF **100** may include at least some of the same routing intelligence conventionally contained in nodes **104**, **106**, and **108** and use openflow controller **102** to control switching and routing performed by nodes **104**, **106**, and **108**. Thus, PCRF **100** may control nodes using the openflow protocol in addition to or instead of a layer 7 protocol, such as Diameter.

[0012] Figure 2 is a block diagram illustrating an exemplary architecture for a software-defined network including PCRF **100** with integrated openflow controller **102**. Referring to Figure 2, PCRF **100** controls BRAS/BNG **106**, GGSN **108A**, PDN-GW/S-GW **108B**, eNode B **104**, Wi-Fi access point **114** and openflow switches/routers **116** using openflow. PCRF **100** may also communicate with **DSR 118** and HSS **120** using any suitable protocol, such as Diameter. PCRF **100** may support various applications, such as content streaming **122**, voice over LTE **124**, rich communications suite (RCS) **126**, cloud services **128**, and business applications **130**.

[0013] Figure 3 is a flow diagram illustrating exemplary messages that may be exchanges when a node such as BRAS/BNG **106** is controlled by PCRF **100** using openflow. Referring to Figure 3, in line 1, a user element **300** sends an initial Ethernet frame or an IP packet to the network. BRAS/BNG **106** receives the frame or packet, performs a lookup in its flow table, and determines that there are no matching entries. Accordingly, in line 2, BRAS/BNG **106** sends the frame or packet to PCRF **100** to determine what policy to apply to the frame or packet and to subsequent frames or packets in the same flow as the Ethernet frame or IP packet. Openflow controller **102** receives the frame or packet and determines the policy to apply to the frame or packet. In line 3, openflow controller **102** sends an openflow add command instructing BRAS/BNG **106** to add an entry to its flow table to implement a policy for frames associated with the same flow as the received Ethernet frame. Subsequent Ethernet frames or IP packets associated with the same flow may be switched by BRAS/BNG **106** using the entry added to its flow table by openflow controller **102**.

[0014] It will be understood that various details of the presently disclosed subject matter may be changed without departing from the scope of the presently disclosed subject matter. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation.

Claims

1. A system for providing a policy controlling network, the system comprising:

   a policy and charging rules function, PCRF, (100) configured to determine policies to apply to network sessions or users; and
   an openflow controller (102) integrated with the PCRF and configured to provide instructions to telecommunications network elements in an openflow protocol to implement the policies, **characterised in that** the PCRF is configured to receive an initial frame or packet from a broadband remote access server/broadband network gateway, BRAS/BNG, (106) to determine what policy to apply to the initial frame or packet and to subsequent frames or packets in the same flow, and wherein the openflow controller is adapted to receive the initial frame or packet and is configured to determine the policy to apply to the initial packet or frame and to subsequent frames or packets in the same flow and is further configured to send an openflow add command to the BRAS/BNG (106), instructing the BRAS/BNG (106) to add an entry to its flow table to implement a policy for the subsequent frames or packets in the same flow as the initial frame or packet.

2. The system of claim 1 wherein the openflow controller is configured to provide instructions in the openflow protocol to one or more of a gateway GPRS support node, GGSN, (108A) a packet data network gateway / server gateway, PDN-GW/S-GW, (108B) an evolved node B, eNode B, (104).

3. The system of claim 1 wherein the openflow controller is configured to provide instructions in the openflow protocol to one or more of a Wi-Fi access point (114), a switch (116), and a router (118).

4. The system of claim 1 wherein the PCRF includes a non-openflow interface (109) for providing instructions to at least some of the telecommunications net-

work elements using a non-openflow protocol.

5. The system of claim 4 wherein the non-openflow protocol comprises a Diameter protocol.

6. The system of claim 1 wherein the PCRF is configured to communicate with a home subscriber server, HSS, (120) using Diameter.

7. The system of claim 1 wherein the PCRF is configured to communicate with a Diameter signaling router, DSR, (118) using Diameter.

8. The system of claim 1 wherein the PCRF includes a non-openflow interface (109) for controlling non-openflow devices.

9. The system of claim 8 wherein the non-openflow devices include an online charging system, OCS (110).

10. The system of claim 8 wherein the non-openflow devices include a deep packet inspection, DPI, node (112).

Patentansprüche

1. System zum Bereitstellen eines Richtliniensteuerungsnetzwerks, wobei das System Folgendes umfasst:

eine Richtlinien- und Vergebührungsregeln-Funktion (*policy and charging rules function* - PCRF) (100), die konfiguriert ist, Richtlinien zu bestimmen, die auf Netzwerksitzungen oder Benutzer anzuwenden sind; und
eine OpenFlow-Steuerung (102), die in die PCRF integriert ist und konfiguriert ist, Anweisungen an Telekommunikationsnetzwerkelemente in einem OpenFlow-Protokoll bereitzustellen, um die Richtlinien zu implementieren, **dadurch gekennzeichnet, dass** die PCRF konfiguriert ist, einen anfänglichen Rahmen oder ein anfängliches Paket von einem Broadband-Remote-Access-Server/einem Broadband-Network-Gateway (BRAS/BNG) (106) zu empfangen, um zu bestimmen, welche Richtlinie auf den anfänglichen Rahmen oder das anfängliche Paket und auf darauffolgende Rahmen oder Pakete im selben Fluss anzuwenden ist, und wobei die OpenFlow-Steuerung angepasst ist, den anfänglichen Rahmen oder das anfängliche Paket zu empfangen und konfiguriert ist, die Richtlinie zu bestimmen, die auf das anfängliche Paket oder den anfänglichen Rahmen und auf darauffolgende Rahmen oder Pakete im selben Fluss anzuwenden ist, und ferner konfiguriert ist, einen OpenFlow-Befehl hinzuzufügen an den/das BRAS/BNG (106) zu senden, der den BRAS/BNG (106) dazu anweist, einen Eintrag in seiner Flusstabelle hinzuzufügen, um eine Richtlinie für die darauffolgenden Rahmen oder Pakete im selben Fluss wie für den anfänglichen Rahmen oder das anfängliche Paket zu implementieren.

2. System nach Anspruch 1, wobei die OpenFlow-Steuerung konfiguriert ist, Anweisungen im OpenFlow-Protokoll an einen oder mehrere von einem Gateway-GPRS-Support-Knoten (GGSN) (108A), einem Paketdaten-Netzwerk-Gateway/-Server-Gateway (PDN-GW/S-GW) (108B), einem weiterentwickelten Knoten (*evolved Node B* - eNode B) (104) bereitzustellen.

3. System nach Anspruch 1, wobei die OpenFlow-Steuerung konfiguriert ist, Anweisungen im OpenFlow-Protokoll an einen oder mehrere von einem WLAN-Zugangspunkt (114), einem Switch (116) und einem Router (118) bereitzustellen.

4. System nach Anspruch 1, wobei die PCRF eine Nicht-OpenFlow-Schnittstelle (109) zum Bereitstellen von Anweisungen an wenigstens einige der Telekommunikationsnetzwerkelemente unter Verwendung eines Nicht-OpenFlow-Protokolls enthält.

5. System nach Anspruch 4, wobei das Nicht-OpenFlow-Protokoll ein Diameter-Protokoll umfasst.

6. System nach Anspruch 1, wobei die PCRF konfiguriert ist, mit einem Home-Subscriber-Server (HSS) (120) unter Verwendung von Diameter zu kommunizieren.

7. System nach Anspruch 1, wobei die PCRF konfiguriert ist, mit einem Diameter-Signalisierungsrouter (DSR) (118) unter Verwendung von Diameter zu kommunizieren.

8. System nach Anspruch 1, wobei die PCRF eine Nicht-OpenFlow-Schnittstelle (109) zum Steuern von Nicht-OpenFlow-Vorrichtungen enthält.

9. System nach Anspruch 8, wobei die Nicht-OpenFlow-Vorrichtungen ein Online-Vergebührungssystem (*online charging system* - OCS) (110) enthalten.

10. System nach Anspruch 8, wobei die Nicht-OpenFlow-Vorrichtungen einen Deep-Packet-Inspection-(DPI-)Knoten (112) enthalten.

Revendications

1. Système de fourniture d'un réseau de commande

de politique, le système comprenant :

une fonction de règles de facturation et de politique, PCRF, (100) configurée pour déterminer des politiques à appliquer à des sessions ou à des utilisateurs de réseau ; et
un dispositif de commande en flux ouvert (102) intégré à la PCRF et configuré pour fournir des instructions à des éléments de réseau de télécommunications dans un protocole en flux ouvert pour mettre en oeuvre les politiques, **caractérisé en ce que** la PCRF est configurée pour recevoir une trame ou un paquet initial(e) en provenance d'un serveur d'accès à distance à large bande/d'une passerelle de réseau à large bande, BRAS/BNG, (106) pour déterminer quelle politique appliquer à la trame ou au paquet initial(e) et à des trames ou paquets ultérieur(e)s dans le même flux, et dans lequel le dispositif de commande en flux ouvert est adapté pour recevoir la trame ou le paquet initial(e) et est configuré pour déterminer la politique à appliquer au paquet ou à la trame initial(e) et à des trames ou paquets ultérieur(e)s dans le même flux et est en outre configuré pour envoyer un ordre d'ajout en flux ouvert au BRAS/BNG (106), donnant l'instruction au BRAS/BNG (106) d'ajouter une entrée à sa table de flux pour mettre en oeuvre une politique pour les trames ou paquets ultérieur(e)s dans le même flux en tant que trame ou paquet initial(e).

2. Système selon la revendication 1, dans lequel le dispositif de commande en flux ouvert est configuré pour fournir des instructions dans le protocole en flux ouvert à un ou plusieurs d'un noeud de support GPRS de passerelle, GGSN, (108A) d'une passerelle de réseau à commutation de paquet/passerelle de serveur, PDN-GW/S-GW, (108B) d'un noeud B évolué, eNoeud B, (104).

3. Système selon la revendication 1, dans lequel le dispositif de commande en flux ouvert est configuré pour fournir des instructions dans le protocole en flux ouvert à un ou plusieurs d'un point d'accès Wi-Fi (114), d'un commutateur (116) et d'un routeur (118).

4. Système selon la revendication 1, dans lequel la PCRF comporte une interface non en flux ouvert (109) pour fournir des instructions à au moins certains des éléments de réseau de télécommunications à l'aide d'un protocole non en flux ouvert.

5. Système selon la revendication 4, dans lequel le protocole non en flux ouvert comprend un protocole Diameter.

6. Système selon la revendication 1, dans lequel la PCRF est configurée pour communiquer avec un serveur d'abonné résidentiel, HSS, (120) à l'aide de Diameter.

7. Système selon la revendication 1, dans lequel la PCRF est configurée pour communiquer avec un routeur de signalisation Diameter, DSR, (118) à l'aide de Diameter.

8. Système selon la revendication 1, dans lequel la PCRF comporte une interface non en flux ouvert (109) pour commander des dispositifs non en flux ouvert.

9. Système selon la revendication 8, dans lequel les dispositifs non en flux ouvert comportent un système de facturation en ligne, OCS (110).

10. Système selon la revendication 8, dans lequel les dispositifs non en flux ouvert comportent un noeud d'inspection approfondie des paquets, DPI, (112).

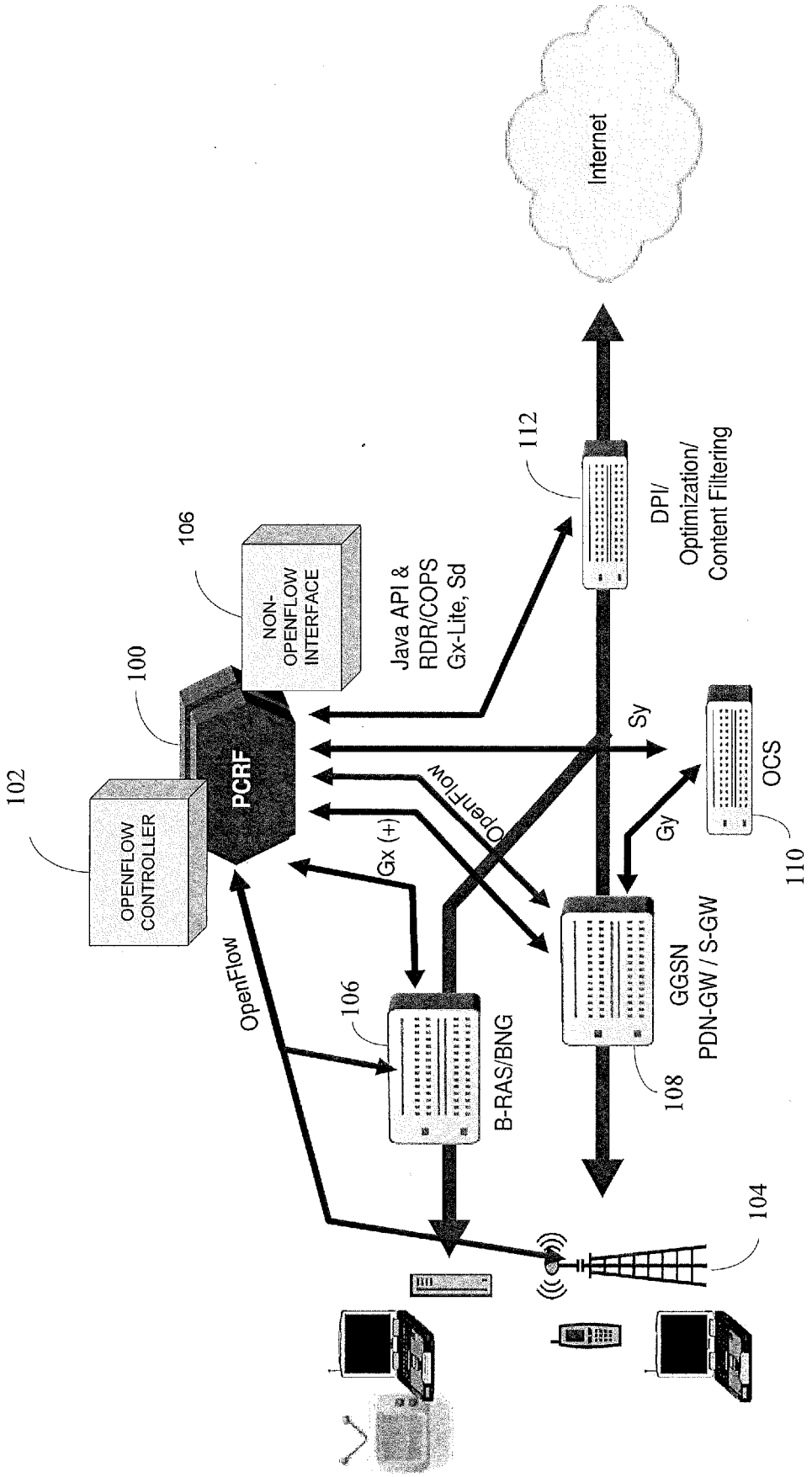
Internet
112
DPI/
Optimization/
Content Filtering
106
NON-
OPENFLOW
INTERFACE
Java API &
RDR/COPS
Gx-Lite, Sd
100
PCRF
102
OPENFLOW
CONTROLLER
Sy
OpenFlow
Gx (+)
Gy
OCS
110
OpenFlow
106
B-RAS/BNG
GGSN
PDN-GW / S-GW
108
104

FIG. 1

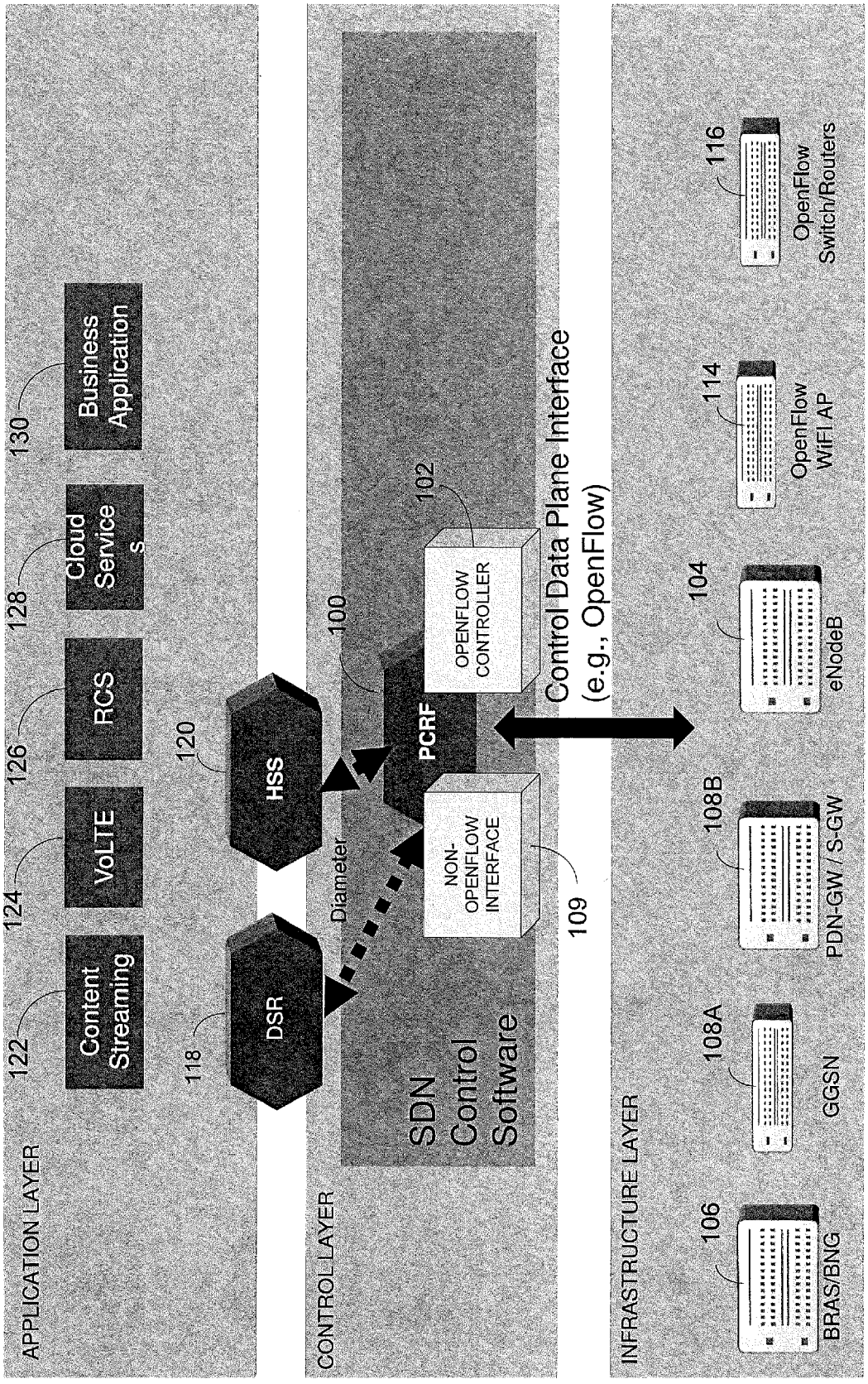
APPLICATION LAYER
Content Streaming
VoLTE
RCS
Cloud Service s
Business Application
122
124
126
128
130
118
DSR
120
HSS
CONTROL LAYER
Diameter
100
PCRF
SDN Control Software
NON-OPENFLOW INTERFACE
109
OPENFLOW CONTROLLER
102
Control Data Plane Interface (e.g., OpenFlow)
INFRASTRUCTURE LAYER
106
BRAS/BNG
108A
GGSN
108B
PDN-GW / S-GW
104
eNodeB
114
OpenFlow WiFI AP
116
OpenFlow Switch/Routers

FIG. 2

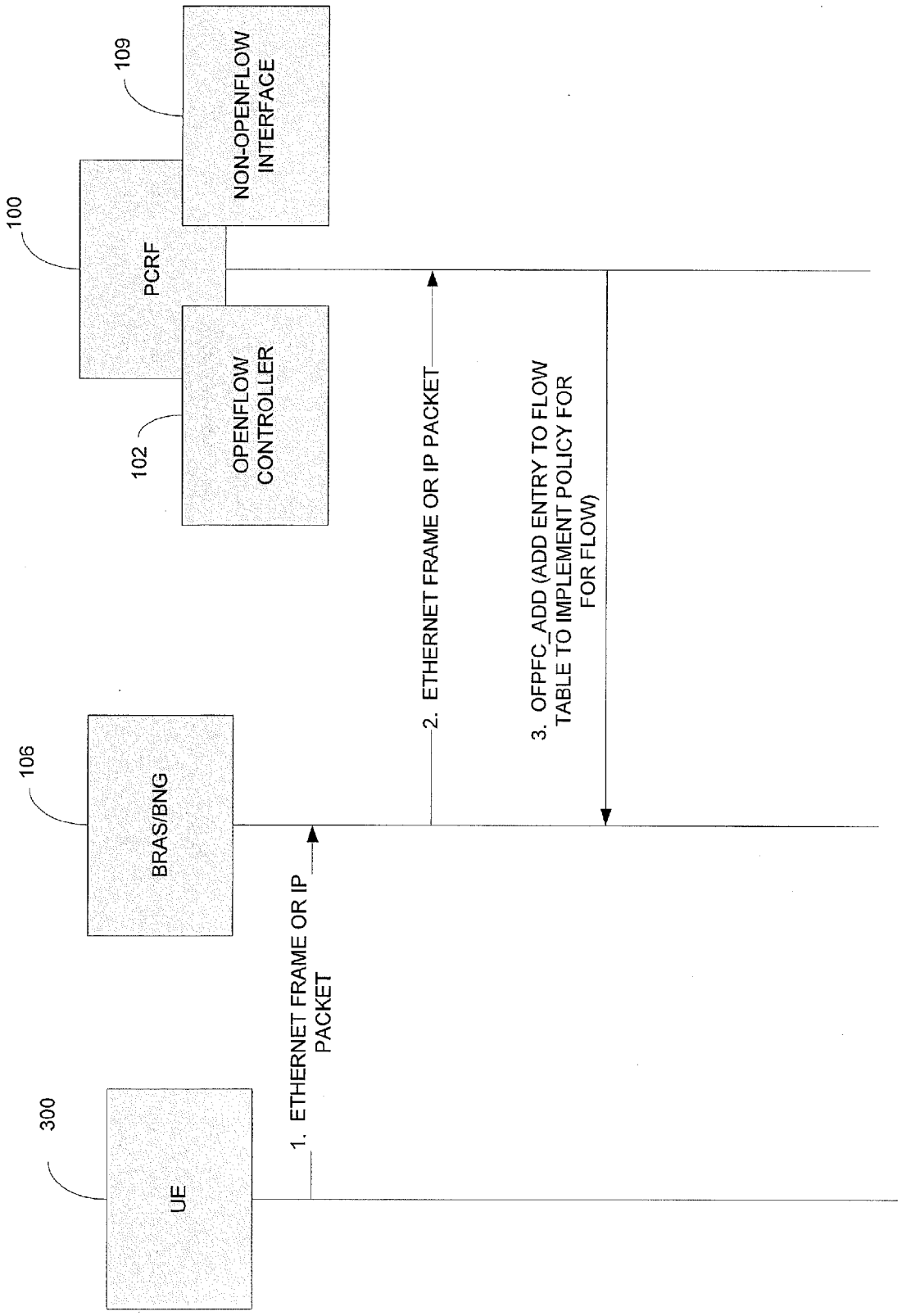
300
UE
106
BRAS/BNG
100
PCRF
102
OPENFLOW CONTROLLER
109
NON-OPENFLOW INTERFACE
1. ETHERNET FRAME OR IP PACKET
2. ETHERNET FRAME OR IP PACKET
3. OFPFC_ADD (ADD ENTRY TO FLOW TABLE TO IMPLEMENT POLICY FOR FOR FLOW)

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- *Openflow Switch Specification,* 28 February 2011 **[0004]**
- **LI ERRAN et al.** *CellSDN: "Software-Defined Cellular Networks,* 30 April 2012 **[0005]**