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(54) **SECURITY SERVICES FOR END USERS THAT UTILIZE SERVICE CHAINING**

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(57) **ABSTRACT**

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Embodiments described herein provide security for end users of User Equipment (UE) that utilize service chaining for Service Data Flows (SDFs). One embodiment comprises a Policy and Charging Rules Function (PCRF) that determines that a service chain is enabled for a SDF requested by an end user of a UE. The PCRF identifies a service function implemented in the service chain that processes the SDF based on a generic security policy, and identifies a security rule for the end user for filtering the SDF by the service function. The PCRF provides the security rule to the service function for filtering the SDF within the service chain.

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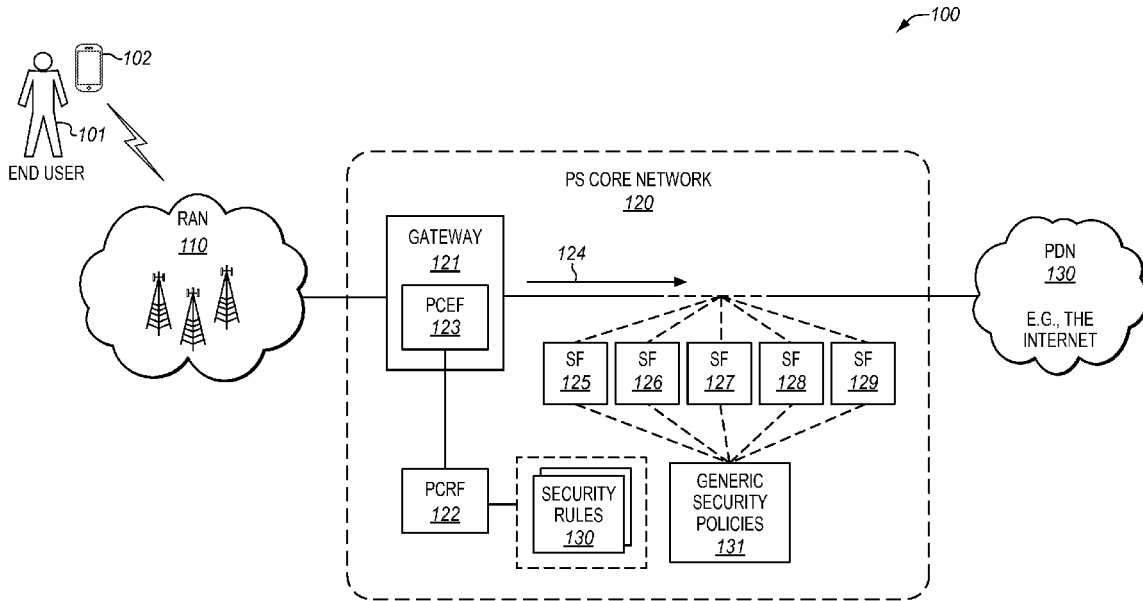


FIG. 1

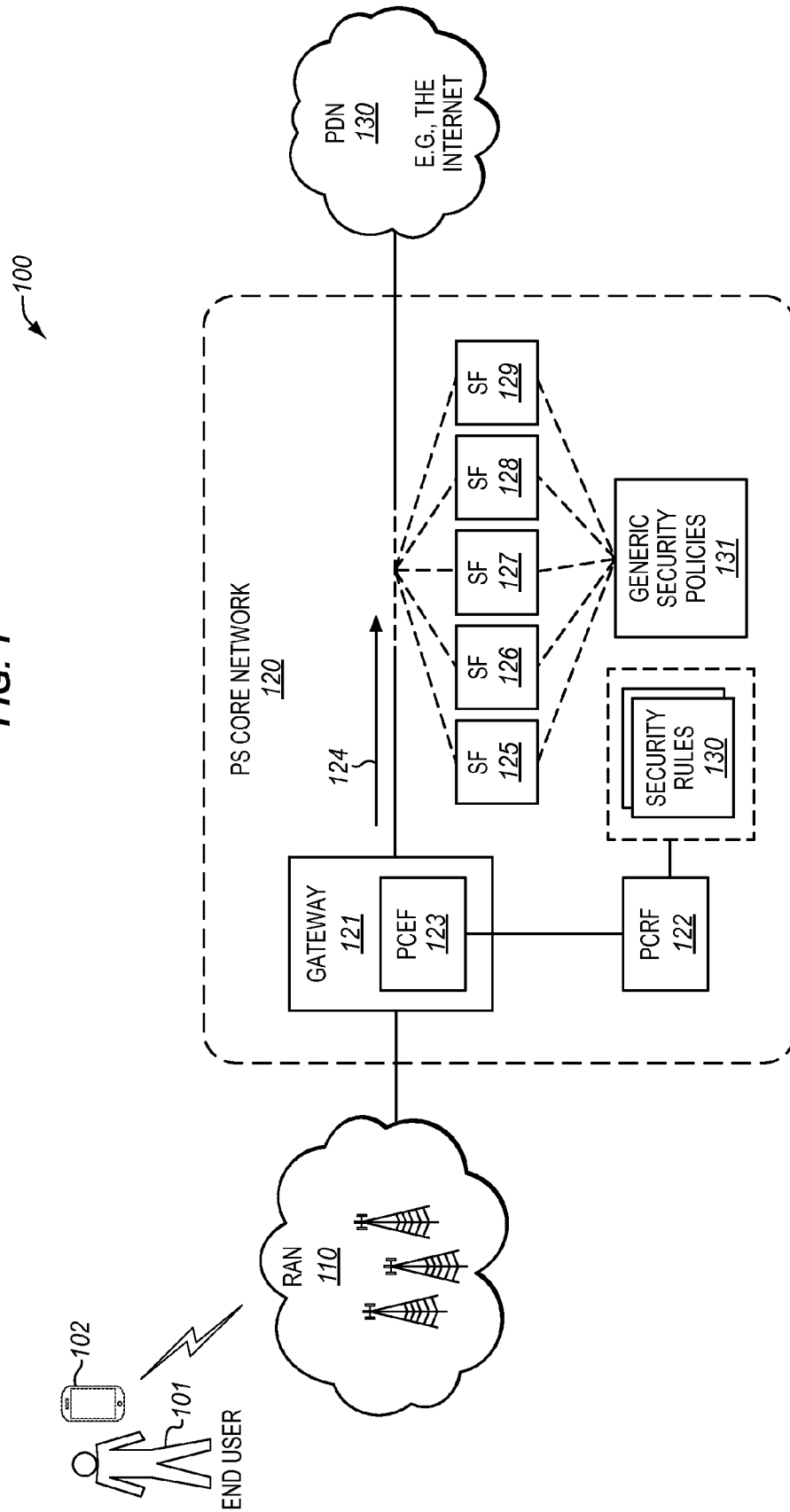


FIG. 2

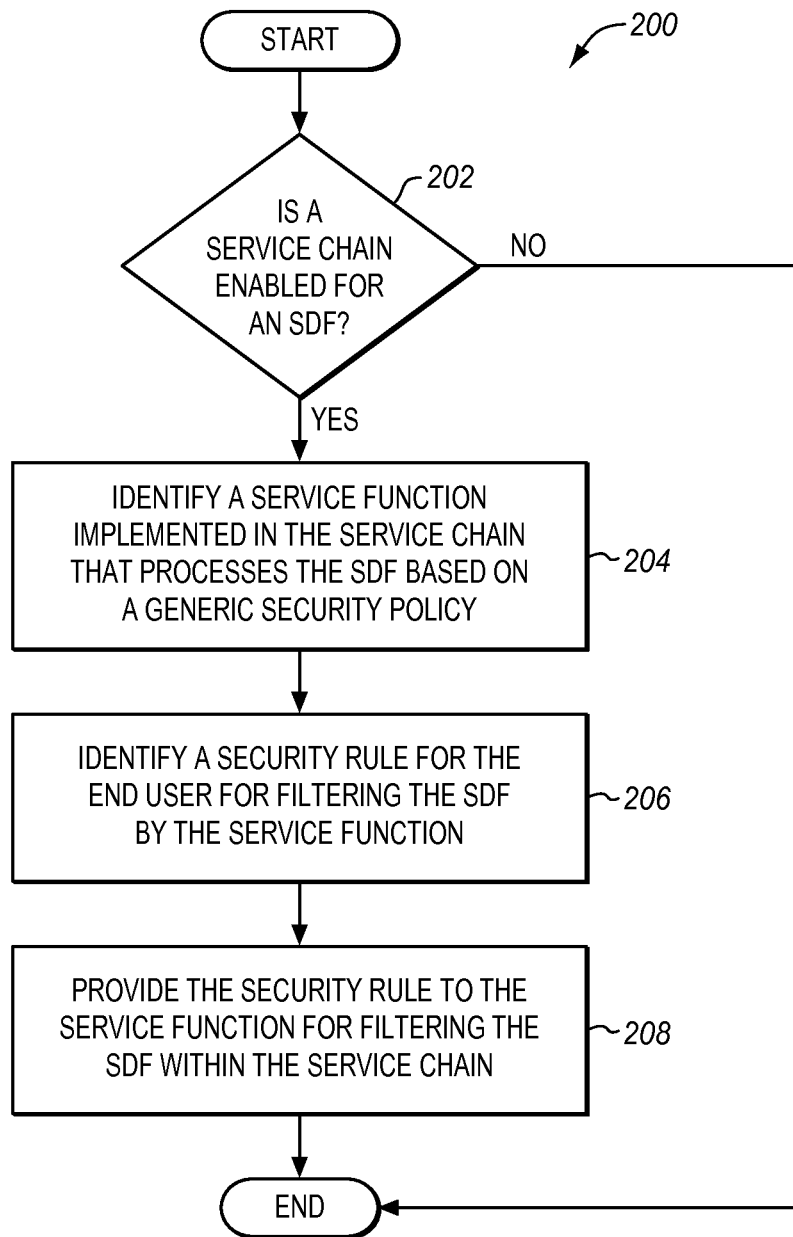


FIG. 3

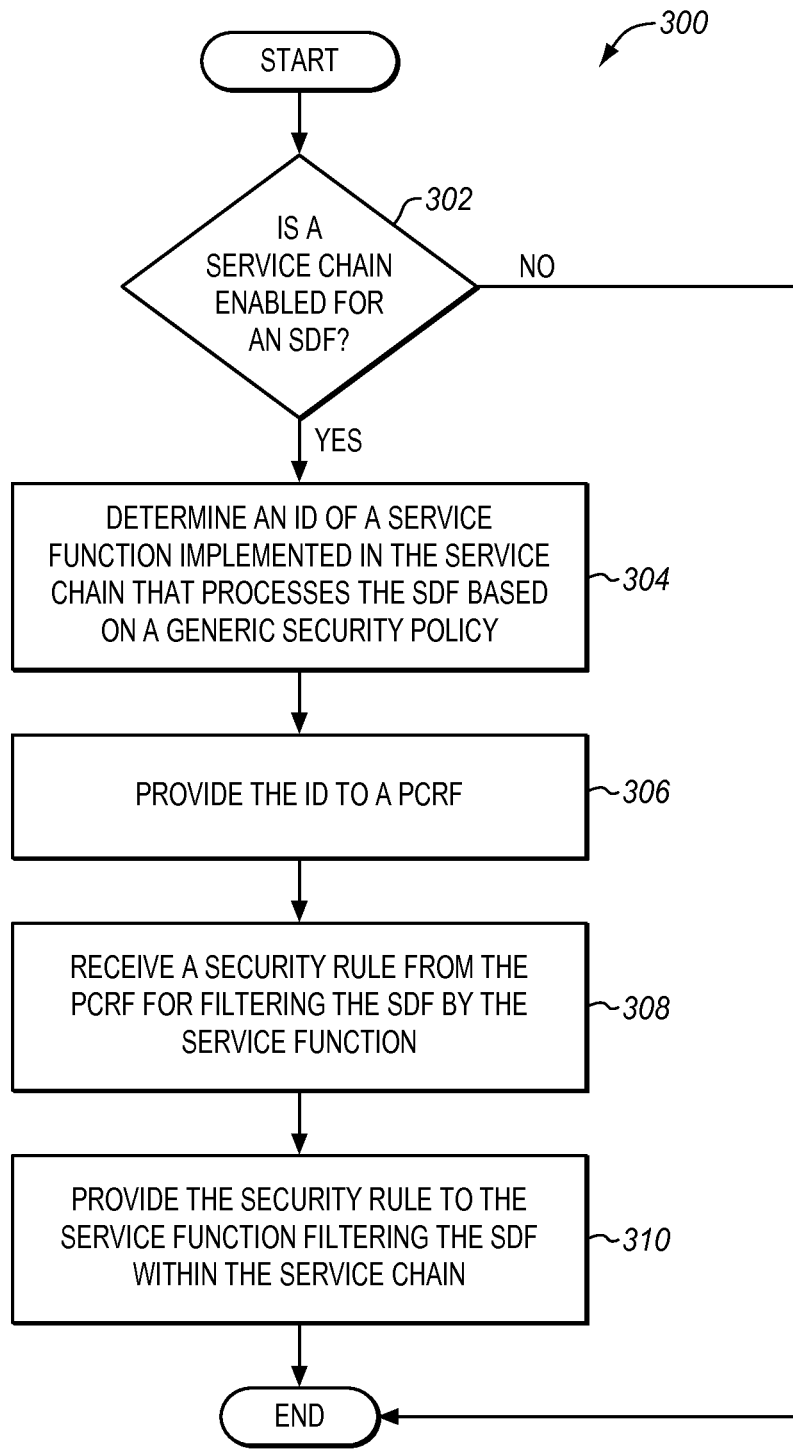


FIG. 4

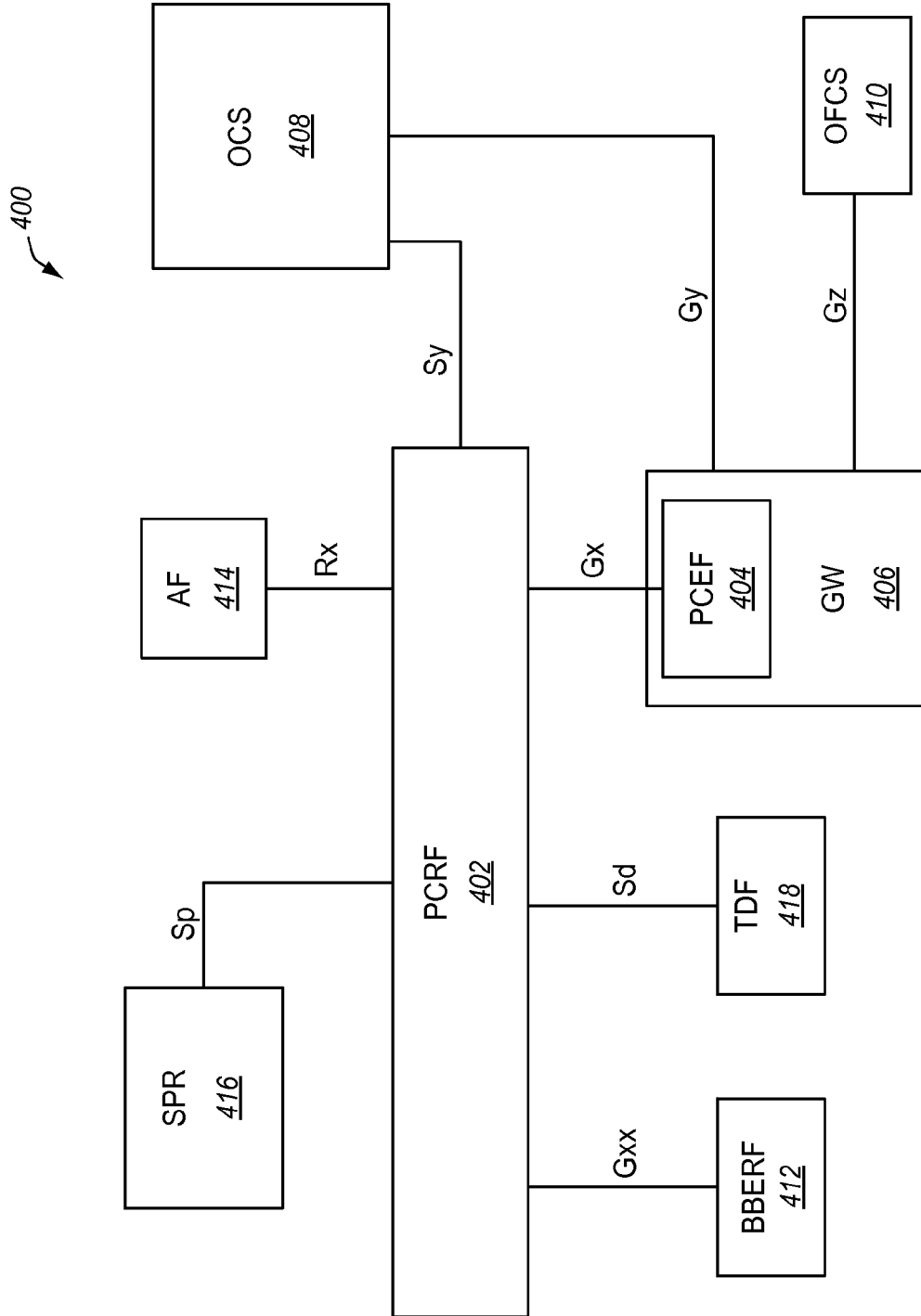
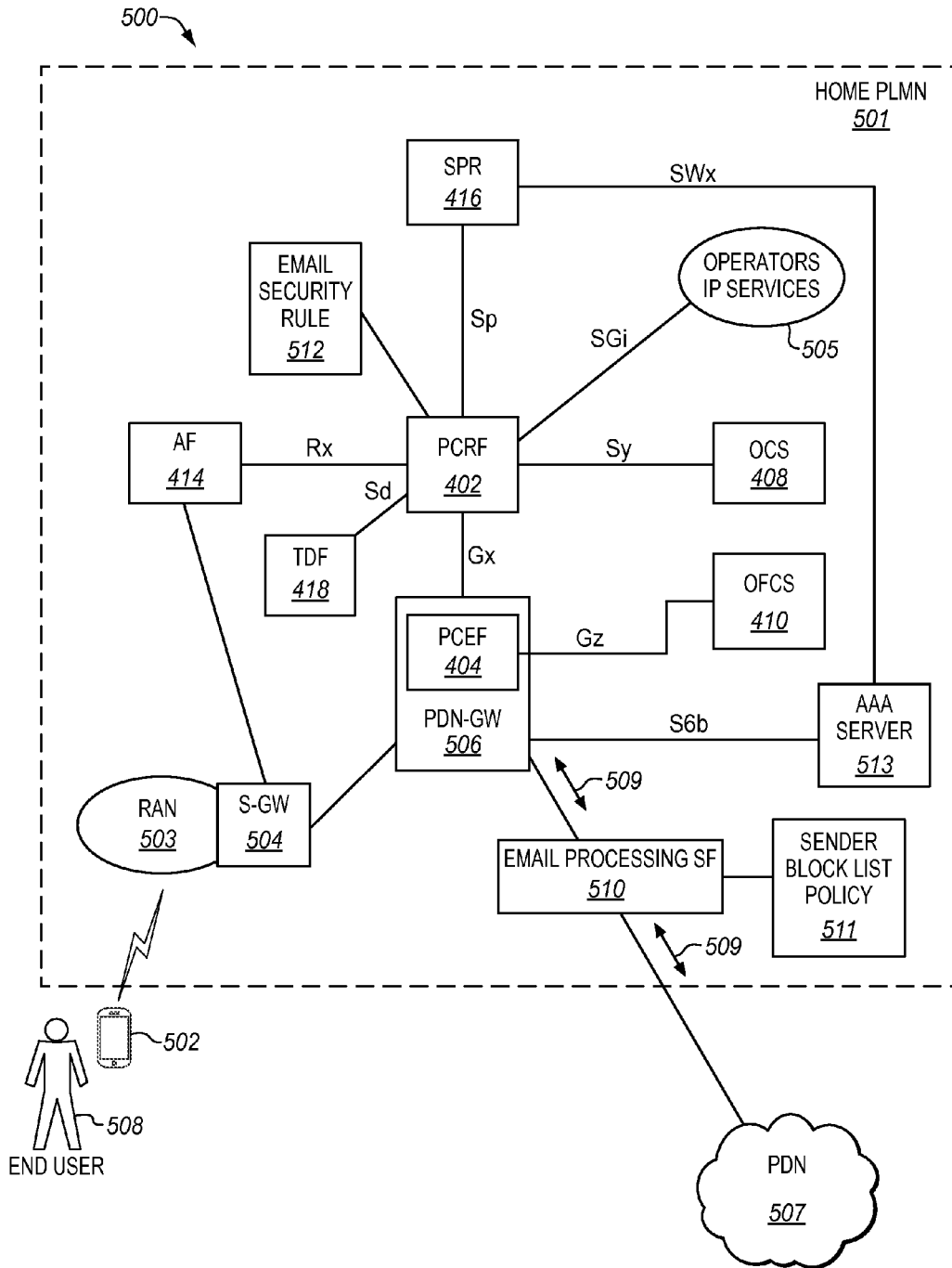


FIG. 5



SECURITY SERVICES FOR END USERS THAT UTILIZE SERVICE CHAINING

FIELD OF THE INVENTION

[0001] The invention is related to the field of mobile communications technology.

BACKGROUND

[0002] A 3G/4G network provides end users with mobile data services utilizing User Equipment (UE) such as smartphones, laptops, tablets, and smart watches. For example, an end user may utilize a UE to engage in sessions with a 3G/4G network in order to exchange packets of data with a Packet Data Network (PDN) such as the Internet.

[0003] When an end user utilizes a UE to initiate a session over a 3G/4G network (e.g., an IP Connectivity Access Network (IP-CAN) session), the session request from the UE includes a description of the requested service (e.g., online gaming, IP-TV, etcetera). The 3G/4G network reserves a bearer path (e.g., an IP-CAN bearer) of a defined capacity, delay, and bit error rate. A flow of packets over the 3G/4G network may then begin for the service, which is referred to as a Service Data Flow (SDF).

[0004] Service chaining is the concept of applying an ordered set of services to an SDF using service enablers. Besides basic routing and forwarding functions, a service chain may include Transmission Control Protocol (TCP) optimization, video optimization, advertisement insertion, and/or website optimization. 3G/4G service providers are increasingly moving towards the use of service chains within their networks, because service chains can be used to implement value added services for the end user that can be monetized.

SUMMARY

[0005] Embodiments described herein provide security for end users of User Equipment (UE) that utilizes service chaining for Service Data Flows (SDFs). When a SDF passes through a service chain, a service function implemented in the service chain is identified. The service function in the service chain processes the SDF based on a generic security policy. For instance, the generic security policy may be a network-wide policy implemented by a network operator for SDFs having a particular media type. A security rule is identified for the end user for filtering the SDF by the service function, and the security rule is provided to the service function for filtering the SDF within the service chain. Utilizing security rules defined for an end user, customized filtering policies may be implemented specifically for the end user that are more detailed and specific to a particular end user than a generic security policy that may be applied to SDFs by a network operator.

[0006] One embodiment comprises a Policy and Charging Rules Function (PCRF) that is configured to determine that a service chain is enabled for a SDF requested by an end user of a UE. The PCRF is configured to identify a service function implemented in the service chain that processes the SDF based on a generic security policy, and to identify a security rule for the end user for filtering the SDF by the service function. The PCRF is configured to provide the security rule to the service function for filtering the SDF within the service chain.

[0007] In an embodiment, the PCRF is configured to provide the security rule to the service function via a Policy and Charging Enforcement Function (PCEF).

[0008] In an embodiment, the PCRF is configured to transmit the security rule to the PCEF within an enhanced Diameter message, where an Attribute Value Pair (AVP) is defined for the security rule in the enhanced Diameter message.

[0009] In an embodiment, the enhanced Diameter message comprises one of a Credit Control Answer (CCA) message and a Re-Auth Request (RAR) message with new security AVPs.

[0010] In an embodiment, the new security AVPs comprises at least one of a Security-Rule-Install AVP, a Security-Rule-Remove AVP, a Security-Rule-Definition AVP, a Security-Rule-Base-Name AVP, a Security-Rule-Name AVP, a Security-Filter AVP, a Security-Rule-Activate-Time AVP, and a Security-Rule-Deactivate-Time AVP.

[0011] In an embodiment, the security rule comprises filtering content in the SDF by the service function.

[0012] In an embodiment, the security rule comprises blocking the SDF by the service function based on at least one of a location of the end user and a time-of-day for the end user.

[0013] Another embodiment comprises a method for providing security for end users of UE that utilize service chaining for SDFs. The method comprises determining, by a PCRF, that a service chain is enabled for a SDF requested by an end user of a UE. The method further comprises identifying, by the PCRF, a service function implemented in the service chain that processes the SDF based on a generic security policy. The method further comprises identifying, by the PCRF, a security rule for the end user for filtering the SDF by the service function. The method further comprises providing, by the PCRF, the security rule to the service function for filtering the SDF within the service chain.

[0014] Another embodiment comprises a PCEF that is configured to determine that a service chain is enabled for a SDF requested by an end user of UE. The PCEF is configured to determine an ID of a service function implemented in the service chain that processes the SDF based on a generic security policy, and to provide the ID to a PCRF. The PCEF is configured to receive a security rule from the PCRF for filtering the SDF by the service function, and to provide the security rule to the service function for filtering the SDF within the service chain.

[0015] Other example embodiments may be described below.

DESCRIPTION OF THE DRAWINGS

[0016] Some embodiments of the invention are now described, by way of example only, and with reference to the accompanying drawings. The same reference number represents the same element or the same type of element on all drawings.

[0017] FIG. 1 illustrates a communication system in an example embodiment.

[0018] FIG. 2 is a flow chart illustrating a method for providing security for end users of UE that utilize service chaining for SDFs in an example embodiment.

[0019] FIG. 3 is a flow chart illustrating another method for providing security for end users of UE that utilize service chaining for SDFs in an example embodiment.

[0020] FIG. 4 illustrates a PCC architecture for a packet core network in an example embodiment.

[0021] FIG. 5 illustrates an LTE network using the PCC architecture of FIG. 4 in an example embodiment.

DESCRIPTION OF EMBODIMENTS

[0022] The figures and the following description illustrate specific example embodiments of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within the scope of the invention. Furthermore, any examples described herein are intended to aid in understanding the principles of the invention, and are to be construed as being without limitation to such specifically recited examples and conditions. As a result, the invention is not limited to the specific embodiments or examples described below, but by the claims and their equivalents.

[0023] FIG. 1 illustrates a communication system 100 in an example embodiment. Communication system 100 may represent a Long Term Evolution (LTE) network or another type of Third Generation (3G), Fourth Generation (4G), or later generation communication network. Communication system 100 includes a Radio Access Network (RAN) 110 and a Packet-Switched (PS) core network 120. RAN 110 and PS core network 120 provide mobile communication service to end user 101 utilizing devices, such as User Equipment (UE) 102. PS core network 120 includes a gateway 121 that communicate with a Packet Data Network (PDN) 130, such as the Internet. Some examples of gateway 121 include a Packet Data Network Gateway (PGW) of an Evolved Packet Core (EPC) network as described in the LTE standards (which may include a Policy and Charging Enforcement Function (PCEF) 123. Another example of gateway 121 is a Gateway GPRS Support Node (GGSN) of a GPRS network. PS core network 120 may include many more network elements that are not shown in FIG. 1.

[0024] PS core network 120 establishes and maintains sessions for UE 102 for end user 101 to allow UE 102 to access data services. UE 102 is a mobile terminal, such as a mobile phone, a computer, a tablet, etc. UE 102 is able to access PS core network 120 through RAN 110, which comprises any type of network that interfaces UEs with PS core network 120. Some examples of RAN 110 are a UMTS Terrestrial Radio Access Network (UTRAN), an enhanced UTRAN (E-UTRAN), an Interworking-Wireless Local Area Network (I-WLAN), etc. The sessions over PS core network 120 as described herein may be referred to as an IP Connectivity Access Network (IP-CAN) session. An IP-CAN session is an association between UE 102 (represented by an IPv4 address and/or an IPv6 prefix) and PDN 130. An IP-CAN session may incorporate one or more IP-CAN bearers. An IP-CAN bearer is an IP transmission path of a defined capacity, delay and bit error rate, etc. Each IP-CAN bearer may be made up of one or more Service Data Flows (SDFs) 124, which includes a flow of packets.

[0025] Communication system 100 provides services, referred to as value-added services, to data traffic that is exchanged between UE 102 and PDN 130 utilizing various service functions 125-129. For example, some service functions 125-129 include traffic compression, video optimization, web caching, HTTP header enrichment, firewalls, content scanning, malware detection, etc. Service functions 125-129 illustrated in FIG. 1 may implement any number of services to SDF 124 in a service chain. As used herein the term "function" refers to a tangible collection of one or more

electronic entities configured to provide the described functionality of the function. Thus, a function may be or include a processor, controller, finite state machine, discrete and/or integrated electronic features configured by instructions (e.g. software) and/or hard-wired to provide all or a portion of the described functionality.

[0026] A service chain is an ordered set of services that are interconnected in series through the network to support an application. Service chaining allows multiple service nodes to be included in a service path so that the packets that belong to a particular packet flow can travel through the service nodes in the service chain. The service path consists of an ordered list of services to be applied to a packet flow and it is used to define the service chain. FIG. 1 illustrates that the value-added services are provided by a series of specialized service functions 125-129 that apply the services to SDF 124. Service functions 125-129 are organized in series in any desired sequence depending on the services that are applied to SDF 124. Such services may depend upon any number of factors, such as the media type of SDF 124. For instance, if SDF 124 is an HTTP session, then the order and/or type of service function applied to SDF 124 may be different than if SDF 124 is a Voice over IP (VoIP) call.

[0027] Service chaining can be implemented in a number of ways in communication system 100 as a matter of design choice. For instance, a server, e.g. PCEF 123, or specialized service chain enforcement point (at network ingress for example) could stack a set of IDs that identify service functions 125-129 (which may also be referred to as an application ID) onto a packet as it is switched through communication network 100. The IDs indicate the various service functions and order of the service functions in the service chain. The first ID causes the network to route the packet to the first service function in the chain. The first service function pops its ID from the stack, and forwards the packet to the next service function indicated by the next ID in the stack. This process continues as the packet progresses through the service chain.

[0028] In a service chaining environment, it is likely that a network operator for communication system 100 may define generic security policies 131 for one or more service functions 125-129 that may be considered as default settings for service functions 125-129. For instance, if a service chain for an email data session is in place, then generic security policies 131 may be put in place by the network operator to block certain senders from being able to transmit email across communication network 100. However, this type of network-wide policy lacks any specific security considerations for end user 101, which may have specialized security concerns. For instance, end user 101 may be a minor child, and a parent of the child may have specific security concerns that are more detailed and specific than what a network-wide policy could provide.

[0029] In FIG. 1, assume for discussion purposes that UE 102 registers with communication network 100 in order to receive services from network 100. At some point, UE 102 requests a session to stream audio, stream video, place a VoIP voice call, play an online game, watch IP-TV, etc., each of which involves a flow of packets referred to as a SDF (e.g., SDF 124). These types of sessions and services are referred to generally as data services.

[0030] Assume further for discussion purposes that end user 101 of UE 102 has security rules 130 that are accessible to PCRF 122. For instance, security rules 130 may be located

within a Home Subscriber Server (HSS) profile for end user **101**, may be stored by a Subscriber Profile Repository (SPR), and/or may be stored by PCRF **122**. In this embodiment, security rules **130** are specific to end user **101** and are implemented by one or more service functions **125-129**. For instance, security rules **130** for end user **101** may be used by one or more service functions **125-129** to remove and/or modify the contents of SDF **124**. Some examples of content based activities that may be performed on SDF **124** include detecting/removing keywords (e.g., from emails, SMS messages, etc.), detecting/removing malware (e.g., from data), detecting/removing malicious HTTP links (e.g., from emails, websites, Short Message Service (SMS) messages, etc.). Security rules **130** may be used by one of service functions **125-129** to temporarily block certain media types of SDF **124**, which may be performed during a certain time-of-day and/or based on a location of end user **101**. For instance, security rules **130** may be used by one or more service functions **125-129** to block SMS messages to/from UE **102** when end user **101** is in school, which may be based on a time-of-day and/or a location of end user **101**.

[0031] FIG. 2 is a flow chart illustrating a method **200** for providing security for end users of UE that utilize service chaining for SDFs in an example embodiment. The steps of method **200** will be described with reference to communication network **100** in FIG. 1, although method **200** may be performed in other networks or systems. The steps of the flow charts described herein are not all-inclusive and may include other steps not shown. The steps may also be performed in an alternative order.

[0032] As SDF **124** flows across PS core network **120**, SDF **124** may be processed by a service chain that includes one or more of the service functions **125-129**. As discussed previously, packets within SDF **124** may be tagged with information that identifies the particular service functions **125-129** and the order that SDF **124** is applied to service functions **125-129**. PCRF **122** determines whether a service chain is enabled for SDF **124** (see step **202** of FIG. 2). To do so, PCRF **122** may analyze, or receive information about, IDs in the packets that identify various service functions **125-129**. This information may be provided to PCRF **122** by PCEF **123** and/or by a Traffic Detect Function (TDF), not shown in FIG. 1, which may be part of a Policy and Charging Control (PCC) architecture for communication network **100**.

[0033] If a service chain is enabled for SDF **124**, PCRF **122** identifies one of service functions **125-129** in the service chain that processes SDF **124** based on generic security policies **131** (see step **204** of FIG. 2). For instance, PCRF **122** may identify service function **125** is part of the service chain for SDF **124**, and that service function **125** is processing SDF **124** using generic security policies **131**. If no service chain is enabled for SDF **124**, then method **200** may end.

[0034] PCRF **122** identifies security rules **130** for end user **101** for filtering SDF **124** by the identified service function (e.g., service function **125**) in step **206**. To identify security rules **130**, PCRF **122** may match an application ID for the identified service function with security rules **130**. For instance, if service function **125** performs an email inspection function for SDF **124**, then one of security rules **130** may pertain to content scanning of emails, to HTTP link removal within emails, to malware detection within emails, etc. Thus, the particular security rules **130** that applies to service function **125** (in continuing with the example), is identified.

[0035] PCRF **122** provides the identified security rule(s) **130** to the identified service function (e.g., service function **125**), in step **208**. PCRF **122** may provide the identified security rule(s) **130** to the service function directly, and/or via PCEF **123**. For instance, PCRF **122** may forward the identified security rules **130** to PCEF **123** within an enhanced Diameter message (e.g., a Credit Control Answer (CCA) message or a Re-Auth Request (RAR) message) that includes new security Attribute Value Pairs (AVPs), which then is able to forward security rules(s) to the identified service functions **125-129**. Utilizing security rules **130**, the identified service functions **125-129** are able to filter SDF **124** for end user **101** within the service chain.

[0036] In some embodiments, the enhanced Diameter message includes one or more security AVPs associated with security rules **130**. The security AVPs may include a Security-Rule-Install AVP, a Security-Rule-Remove AVP, a Security-Rule-Definition AVP, a Security-Rule-Base-Name AVP, a Security-Rule-Name AVP, a Security-Filter AVP, a Security-Rule-Activate-Time AVP, and/or a Security-Rule-Deactivate-Time AVP. These AVPs may be utilized by PCRF **122** and/or PCEF **123** to exchange security-based information within the enhanced Diameter messages (e.g., RAR messages, CCA messages, Credit Control Request (CCR) messages, etc.).

[0037] In some embodiments, security rules **130** may be used to block SDF **124** when certain conditions are met. Security rules **130** may specify that a location and/or a time-of-day for end user **101** is a criterion that may be used by a service function when determining whether to allow SDF **124** to flow across network **100**. For instance, security rules **130** may specify that SDF **124** is blocked during school hours, when end user **101** is on school grounds, etc.

[0038] Communication system **100** is able to provide security services that are specific to end user **101** that go beyond the typical network-wide global security policies **131** that may be implemented by a network operator, and may be more relevant to end user **101**. For instance, if end user **101** is a child, then a parent of the child may wish to block or filter certain types of activity that end user **101** is able to perform using UE **102**. Communication system **100** is capable of achieving this goal in part, by associating security rules **130** with end user **101**.

[0039] FIG. 3 is a flow chart illustrating another method **300** for providing security for end users of UE that utilize service chaining for SDFs in an example embodiment. The steps of method **300** will be described with reference to communication network **100** in FIG. 1, although method **300** may be performed in other networks or systems.

[0040] As SDF **124** flows across PS core network **120**, SDF **124** may be processed by a service chain that includes one or more of the service functions **125-129**. As discussed previously, packets within SDF **124** may be tagged with information that identifies the particular service functions **125-129** and the order that SDF **124** is applied to the service functions **125-129**. PCEF **123** determines whether a service chain is enabled for SDF **124** (see step **302** of FIG. 3). To do so, PCEF **123** may analyze, or receive information about, IDs in the packets that identify various service functions **125-129**. This information may be provided to PCEF **123** by a Traffic Detect Function, which may be part of a Policy and Charging Control (PCC) architecture for communication network **100**.

[0041] If a service chain is enabled for SDF **124**, then PCEF **123** identifies an ID of one of service functions **125-129** in the service chain that processes SDF **124** based on generic secu-

rity policies **131** (see step **304** of FIG. **3**). For instance, PCEF **123** may identify service function **125** is part of the service chain for SDF **124**, and that service function **125** is processing SDF **124** using generic security policies **131**. The ID may be identified within the packets that flow in SDF **124**. If no service chain is enabled for SDF **124**, then method **300** may end.

[0042] PCEF **123** provides the ID to PCRF **122** (see step **306** of FIG. **3**). To do so, PCEF **123** may transmit a CCR message to PCRF **122** that includes the ID for one of the service functions **125-129** (e.g., an ID for service function **125**).

[0043] PCEF **123** receives security rules **130** from PCRF **122** for filtering SDF **124** by one of service functions **125-129** previously identified (see step **308** of FIG. **3**). For instance, PCEF **123** may receive one or more security rules **130** for end user **101** that are tailored to the functionality performed by service function **125**. PCEF **123** may receive security rules **130** in an enhanced Diameter message (e.g., a CCA message or a RAR message).

[0044] PCEF **123** provides security rules **130** to one of service functions **125-129** previously identified (e.g., service function **125**) to allow filtering of SDF **124** within the service chain.

Example

[0045] FIG. **4** illustrates a PCC architecture **400** for a packet core network in an example embodiment. PCC architecture **400** may be used in a Long Term Evolution/Evolved Packet Core (LTE/EPC) network or another type of 4G network. PCC architecture **400** includes a Policy and Charging Rules Function (PCRF) **402** and a Policy and Charging Enforcement Function (PCEF) **404** that together provide a Policy and Charging Control (PCC) solution for a packet core network.

[0046] PCRF **402** encompasses policy control decision and flow-based charging control functionalities. Therefore, PCRF **402** is a node of the packet core network that generates PCC rules for a requested service, which is referred to as a PCC decision. PCRF **402** may include a policy engine (not shown) that makes the PCC decision. Although the term "PCRF" is used in this description, the functionality of PCRF **402** is applicable to any network node that makes policy decisions in a packet core network. PCRF **402** has been enhanced in this embodiment to allow for the implementation of security services for service data flows that are applied on a per-user basis. The particulars of the enhancements will be discussed with regard to FIG. **5**.

[0047] PCEF **404** encompasses service data flow detection, policy enforcement, and flow-based charging functionalities. Therefore, PCEF **404** is a node of the packet core network that enforces the PCC rules for the requested service. For example, PCEF **404** may set up bearer connections for the service, modify existing bearer connections, ensure that only authorized service data flows are established, ensure that QoS limits are not exceeded, etc. PCEF **404** is typically implemented in a gateway (GW) **406**, such as a packet data gateway (P-GW) in an EPC network. PCEF **404** has been enhanced in this embodiment to allow for the implementation of security services for service data flows that are applied on a per-user basis. The particulars of the enhancements will be discussed with regard to FIG. **5**.

[0048] PCC architecture **400** further includes an Online Charging System (OCS) **408**, an Offline Charging System

(OFCS) **410**, a Bearer Binding and Event Reporting Function (BBERF) **412**, an application function (AF) **414**, a Subscriber Profile Repository (SPR) **416**, and a Traffic Detection Function (TDF) **418**. OCS **408** provides online charging for services/sessions accessed by end users. In addition, OCS **408** stores charging rules/plans for the end users which PCRF **402** may use when making a PCC decision. For example, charging rules may define that an end user is a prepaid subscriber, and may define tariffs for different services requested by the end user. PCRF **402** interfaces with OCS **408** via a Diameter Sy interface or any other protocol to exchange charging rules/plans with OCS **408**.

[0049] AF **414** is an element providing applications that require dynamic policy and/or charging control. AF **414** communicates with PCRF **402** to transfer dynamic session information used for PCC decisions, and to receive session-specific information and notifications about bearer level events. For example, AF **414** may provide IP-addresses, port numbers, bit rates, delay sensitivity, etc., for requested services to PCRF **402**. PCRF **402** may then use this information when making the PCC decision. AF **414** communicates with PCRF **402** via a Diameter Rx interface or other suitable protocol interface. One example of AF **414** is a Proxy-Call Session Control Function (P-CSCF) of an IP Multimedia Subsystem (IMS).

[0050] SPR **416** is a logical entity that stores subscriber/subscription related information (i.e., subscriber profiles) used for subscription-based policies, and stores PCC rules generated by PCRF **402**. SPR **416** interfaces with PCRF **402** via a Diameter Sp interface or any other protocol used to exchange policy rules with PCRF **402**. SPR **416** has been enhanced in this embodiment to allow for the implementation of security services for service data flows that are applied on a per-user basis. For instance, SPR **416** may store security rules for end users that utilize a network that PCC **400** operates within. The particulars of the enhancements will be discussed with regard to FIG. **5**.

[0051] TDF **418** is a functional entity that performs application detection, and reports detected applications and their service data flow descriptions to PCRF **402**. TDF **418** may also perform gating, redirection, and bandwidth limitation if a service data flow description cannot be provided to PCRF **402**. In some embodiments, TDF **418** is enhanced to allow for the implementation of security services for service data flows that are applied on a per-user basis. For instance, TDF **418** may perform packet inspection on SDFs to determine if the SDFs are part of a service chain. The particulars of the enhancements will be discussed with regard to FIG. **5**.

[0052] OFCS **410** provides offline charging for services/sessions accessed by end users. OFCS **410** receives charging events from PCEF **404** over a Gz interface and generates Charging Data Records (CDRs), which are sent to a billing system.

[0053] The PCC architecture **400** of FIG. **4** may be implemented in an LTE network or another type of 4G network. FIG. **5** illustrates an LTE network **500** using the PCC architecture **400** of FIG. **4** in an example embodiment. LTE network **500** includes a home Public Land Mobile Network (PLMN) **501**. Home PLMN **501** represents a packet core network where an end user **508** of a UE **502** has subscribed to a service plan. Home PLMN **501** includes the following nodes of a PCC architecture, e.g. the PCC architecture **400**: PCRF **402**, PCEF **404** implemented in a packet data network gateway (PDN-GW) **506**, OCS **408**, OFCS **410**, application

function (AF) **414**, SPR **416**, and TDF **418**. In addition, home PLMN **501** includes a 3GPP Radio Access Network (RAN) **503**, a serving gateway (S-GW) **504**, operator's IP services **505** (e.g., IP Multimedia Subsystem (IMS)), and an Authentication, Authorization and Accounting (AAA) server **513**.

[0054] PDN-GW **506** is connected to one or more Packet Data Networks (PDN) **507**, such as the Internet. When SDF **509** is established for a data service, SDF **509** flows through a service chain. In this example, SDF **509** flows through an email processing service function **510**, which implements a generic security policy **511** to block specific email senders. Policy **511** in this embodiment is configured by the network operator as a generic security policy that is applied to any service data flows that include email content.

[0055] Assume for discussion purposes for this embodiment that end user **508** of UE **502** has subscribed to a security service plan with the operator of network **500**. The security service plan defines email security rules **512** that will be applied to service data flows for end user **508** that include emails. In this embodiment, a parent of end user **508** has configured the security service plan for end user **508** to scan emails sent to end user **508** and to filter out a list of keywords from the emails. This list of keywords for end user **508** is stored in email security rule **512**.

[0056] In FIG. **5**, in order to access a data service, UE **502** sends a request for a data session to RAN **503**. The session request includes a description (e.g., Session Description Protocol (SDP) description) of an initial data service being requested. For example, if the initial data service is a VoIP call, then the session description will specify a VoIP call along with other session parameters. PCEF **404** receives the request to initiate or establish a data session from UE **502**, and then sends a request for PCC rules to PCRF **402** over the Gx reference point. PCRF **402** is tasked with making a PCC decision for the data session. Therefore, PCRF **402** obtains subscriber data and/or charging rules from SPR **416** over the Sp reference point, and generates PCC rules for the initial data service. PCRF **402** then transmits a response to PCEF **404** that includes the PCC rules for the initial data service.

[0057] PCEF **404** then applies the PCC rules to the data session. Applying the PCC rules is also referred to as enforcing the PCC decision. When applying the PCC rules, PCEF **404** enforces policy control through gate enforcement and QoS enforcement, and enforces charging control based on the charging method, which is offline charging in this example. Thus, PCEF **404** establishes the service data flow and collects charging information. PCEF **404** then interfaces with OFCS **410** and sends the offline charging information to OFCS **404**. As the data session is active, SDF **509** flows between PDN-GW **506** and PDN **507**.

[0058] End user **508** generates an email, and a service chain is temporarily established by home PLMN **501** to apply the generic sender block list policy **511** utilizing SF **510**. PCRF **402** detects that a service chain is enabled for SDF **509**, which includes SF **510**. PCRF **402** may detect SF **510** in the chain using an ID assigned to SF **510**. For instance, PCEF **404** may generate a CCR message for PCRF **402** that includes an ID (e.g., an application ID) assigned to SF **510**; PCRF **402** may receive the ID from TDF **418**, etc. PCRF **402** identifies an email security rule **512** for end user **508** that applies to SF **510**. For instance, email security rule **512** may map an application ID for email processing service functions (e.g., SF **510**) to various rules that can be implemented by the service functions. In the example, a parent of end user **508** has created a

rule to filter out a list of key words from the emails. PCRF **402** locates the email security rule **512** for end user **508**, which may be stored at an HSS, at SPR **416**, or within PCRF **402**, and provides the email security rule **512** to SF **510**. PCRF **402** may provide email security rule **512** to SF **510** via PCEF **404** over the Gx reference point. SF **510** receives email security rule **512**, and processes the email from end user **508** in the service chain to remove key words from the email that have been specified by the parent of end user **508** in email security rule **512**.

[0059] One of ordinary skill in the pertinent art will appreciate that the PCC architecture **400** of FIG. **4** may be adapted to other similar embodiments within the scope of the claims, e.g. to provide and enforce other rule sets.

[0060] Any of the various elements shown in the figures or described herein may be implemented as hardware, software, firmware, or some combination of these. For example, an element may be implemented as dedicated hardware. Dedicated hardware elements may be referred to as "processors", "controllers", or some similar terminology. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor (DSP) hardware, a network processor, application specific integrated circuit (ASIC) or other circuitry, field programmable gate array (FPGA), read only memory (ROM) for storing software, random access memory (RAM), non-volatile storage, logic, or some other physical hardware component or module.

[0061] Also, an element may be implemented as non-transitory instructions executable by a processor or a computer to perform the functions of the element. Some examples of instructions are software, program code, and firmware. The instructions are operational when executed by the processor to direct the processor to perform the functions of the element. The instructions may be stored on storage devices that are readable by the processor. Some examples of the storage devices are digital or solid-state memories, magnetic storage media such as a magnetic disks and magnetic tapes, hard drives, or optically readable digital data storage media.

[0062] Although specific embodiments were described herein, the scope of the invention is not limited to those specific embodiments. The scope of the invention is defined by the following claims and any equivalents thereof.

We claim:

1. An apparatus comprising:

a Policy and Charging Rules Function (PCRF) configured to determine that a service chain is enabled for a Service Data Flow (SDF) requested by an end user of User Equipment (UE), to identify a service function implemented in the service chain that processes the SDF based on a generic security policy, and to identify a security rule for the end user for filtering the SDF by the service function;

the PCRF is configured to provide the security rule to the service function for filtering the SDF within the service chain.

2. The apparatus of claim 1 wherein: the PCRF is configured to provide the security rule to the service function via a Policy and Charging Enforcement Function (PCEF).
3. The apparatus of claim 2 wherein: the PCRF is configured to transmit the security rule to the PCEF within an enhanced Diameter message; and an Attribute Value Pair (AVP) is defined for the security rule in the enhanced Diameter message.
4. The apparatus of claim 3 wherein: the enhanced Diameter message comprises one of a Credit Control Answer (CCA) message and a Re-Auth Request (RAR) message with new security AVPs.
5. The apparatus of claim 4 wherein the new security AVPs comprises at least one of:
 a Security-Rule-Install AVP;
 a Security-Rule-Remove AVP;
 a Security-Rule-Definition AVP;
 a Security-Rule-Base-Name AVP;
 a Security-Rule-Name AVP;
 a Security-Filter AVP;
 a Rule-Activate-Time AVP; and
 a Security-Rule-Deactivate-Time AVP.
6. The apparatus of claim 1 wherein the security rule comprises filtering content in the SDF by the service function.
7. The apparatus of claim 1 wherein the security rule comprises blocking the SDF by the service function based on at least one of a location of the end user and a time-of-day for the end user.
8. A method for providing security for end users of User Equipment (UE) that utilize service chaining for a Service Data Flow (SDF), the method comprising:
 determining, by a Policy and Charging Rules Function (PCRF), that a service chain is enabled for a SDF requested by an end user of a UE;
 identifying, by the PCRF, a service function implemented in the service chain that processes the SDF based on a generic security policy;
 identifying, by the PCRF, a security rule for the end user for filtering the SDF by the service function; and
 providing, by the PCRF, the security rule to the service function for filtering the SDF within the service chain.
9. The method of claim 8 wherein providing the security rule to the service function further comprises:
 providing the security rule to the service function via a Policy and Charging Enforcement Function (PCEF).
10. The method of claim 9 wherein providing the security rule to the service function via the PCEF further comprises:
 transmitting an enhanced Diameter message to the PCEF, wherein an Attribute Value Pair (AVP) is defined for the security rule in the enhanced Diameter message.
11. The method of claim 10 wherein:
 the enhanced Diameter message comprises one of a Credit Control Answer (CCA) message and a Re-Auth Request (RAR) message with new security AVPs.
12. The method of claim 11 wherein the new security AVPs comprise at least one of:
 a Security-Rule-Install AVP;
 a Security-Rule-Remove AVP;
 a Security-Rule-Definition AVP;
 a Security-Rule-Base-Name AVP;
 a Security-Rule-Name AVP;
 a Security-Filter AVP;
 a Rule-Activate-Time AVP; and
 a Security-Rule-Deactivate-Time AVP.
13. The method of claim 8 wherein the security rule comprises filtering content in the SDF by the service function.
14. The method of claim 8 wherein the security rule comprises blocking the SDF by the service function based on at least one of a location of the end user and a time-of-day for the end user.
15. An apparatus comprising:
 a Policy and Charging Enforcement Function (PCEF) configured to determine that a service chain is enabled for a Service Data Flow (SDF) requested by an end user of User Equipment (UE), to determine an ID of a service function implemented in the service chain that processes the SDF based on a generic security policy, and to provide the ID to a Policy and Rules Charging Function (PCRF);
 the PCEF is configured to receive a security rule from the PCRF for filtering the SDF by the service function, and to provide the security rule to the service function for filtering the SDF within the service chain.
16. The apparatus of claim 15 wherein:
 the PCEF is configured to receive the security rule from the PCRF within an enhanced Diameter message; and
 an Attribute Value Pair (AVP) is defined for the security rule in the enhanced Diameter message.
17. The apparatus of claim 16 wherein:
 the enhanced Diameter message comprises one of a Credit Control Answer (CCA) message and a Re-Auth Request (RAR) message with new security AVPs.
18. The apparatus of claim 17 wherein the new security AVPs comprise at least one of:
 a Security-Rule-Install AVP;
 a Security-Rule-Remove AVP;
 a Security-Rule-Definition AVP;
 a Security-Rule-Base-Name AVP;
 a Security-Rule-Name AVP;
 a Security-Filter AVP;
 a Rule-Activate-Time AVP; and
 a Security-Rule-Deactivate-Time AVP.
19. The apparatus of claim 15 wherein the security rule comprises filtering content in the SDF by the service function.
20. The apparatus of claim 15 wherein the security rule comprises blocking the SDF by the service function based on at least one of a location of the end user and a time-of-day for the end user.

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