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Inventor(s) | Simon; Sean et al.

CONTROL PLANE USER PLANE (CUPS) CAPABILITIES EXCHANGE

Abstract

Aspects of the subject disclosure may include, for example, obtaining first information identifying each version of a policy rule base to which a control plane architecture of a wireless network has access; obtaining second information identifying each version of a policy rule base to which a user plane architecture of the wireless network has access; selecting as a selected version a common version of a policy rule base to which each of the control plane architecture and the user plane architecture has access; and communicating an identification of the selected version to each of the control plane architecture and the user plane architecture. Other embodiments are disclosed.

Inventors: Simon; Sean (Lynnwood, WA), Herrgoss; Frank (Bellevue, WA)

Applicant: AT&T Intellectual Property I, L.P. (Atlanta, GA)

Family ID: 1000008561392

Assignee: AT&T Intellectual Property I, L.P. (Atlanta, GA)

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. patent application Ser. No. 17/962,978 filed on Oct. 10, 2022. All sections of the aforementioned application are incorporated herein by reference in their entirety.

FIELD OF THE DISCLOSURE
[0002] The subject disclosure relates to control plane user plane (CUPS) capabilities exchange.
BACKGROUND
[0003] In the current Mobile Packet Core implementation for LTE and 5G Option 3X, there is a separation between the control plane (CP) function and the user plane (UP) function. The control plane is used for signaling and coordination for the establishment of mobile subscriber sessions to include GTP-C Mobility Signaling, Diameter Signaling for the purpose of Policy (Gx) or Charging (Gy), Subscriber Identity (RADIUS), Mediation, etc. The user plane handles the Policy Charging and Enforcement (PCEF) function which is directed, managed and controlled through a signaling interface residing on the control plane. At scale, a CP can have many deployed UP which are separate and distinct.
[0004] Between the CP and UP, there is a coordinating mobility interface (Sx) for which subscriber arrival signaling, RSVP type functions, KPIs and other functions occur. More particularly, when CP and UP (CUPS) mobile core elements arrive in-service today and perform their association, they utilize a standards-based Packet Forwarding Control Protocol (PFCP). This 3GPP-based Sx interface is used for functions like Association Setup, Update, Release, Heartbeat, KPI Sharing, Packet Flow Descriptor (PFD) and session management or handling procedures (see, for example, 3GPP 29,244). PFCP itself supports the usage of Vendor-Specific Informational Elements (IE) within the base specification.
[0005] Policies configured on the CP must reside or be downloaded to the user plane to ensure reliable delivery of subscriber treatments, rating and/or attach success. These configurations are traditionally static, meaning they are typically deployed at the same time. In some circumstances, the application of coordination configurations may have an impact to the customer, requiring their mobility session be flushed to vacate the element. A lack of coordinating configurations can lead to failed subscriber attaches, improper treatments, improper rating and/or undesirable alarms attributed to logical mismatches in configuration. This dependency for coordinating configurations adds a significant amount of operational complexity when performing upgrades, migrations and/or aligning new features or services. A "release", or a coordinating configuration between the CP and UP elements, may take a considerable amount of time to deploy using the current deployment methods since only one configuration is typically supported or deployed at one time.
[0006] Certain conventional upgrades typically involve scheduled outages or customer impacts in some circumstances which can have considerable business impacts (e.g., requiring stranded production capacity to which subscribers can be migrated in order to support upgrades and/or policy changes; cut-and-paste or automation which manipulates 100s if not 1000s of lines of code in a maintenance window).

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0007] Reference will now be made to the accompanying drawings, which are not necessarily

drawn to scale, and wherein:

[0008] FIG. **1** is a block diagram illustrating an example, non-limiting embodiment of a communication network in accordance with various aspects described herein.

[0009] FIG. **2**A is a block diagram illustrating an example, non-limiting embodiment of a system (that can function fully or partially within the communication network of FIG. **1**) in accordance with various aspects described herein.

[0010] FIG. **2**B depicts an illustrative embodiment of a method in accordance with various aspects described herein.

[0011] FIG. **2**C depicts an illustrative embodiment of a method in accordance with various aspects described herein.

[0012] FIG. **2**D depicts an illustrative embodiment of a method in accordance with various aspects described herein.

[0013] FIG. **3** is a block diagram illustrating an example, non-limiting embodiment of a virtualized communication network in accordance with various aspects described herein.

[0014] FIG. **4** is a block diagram of an example, non-limiting embodiment of a computing environment in accordance with various aspects described herein.

[0015] FIG. **5** is a block diagram of an example, non-limiting embodiment of a mobile network platform in accordance with various aspects described herein.

[0016] FIG. **6** is a block diagram of an example, non-limiting embodiment of a communication device in accordance with various aspects described herein.

DETAILED DESCRIPTION

[0017] The subject disclosure describes, among other things, illustrative embodiments for control plane user plane (CUPS) capabilities exchange. Other embodiments are described in the subject disclosure.

[0018] One or more aspects of the subject disclosure include a device, comprising: a processing system including a processor; and a memory that stores executable instructions that, when executed by the processing system, facilitate performance of operations, the operations comprising: obtaining first information identifying each version of a policy rule base to which a control plane architecture of a wireless network has access; obtaining second information identifying each version of a policy rule base to which a user plane architecture of the wireless network has access; selecting as a selected version a common version of a policy rule base to which each of the control plane architecture and the user plane architecture has access; and communicating an identification of the selected version to each of the control plane architecture and the user plane architecture.

[0019] One or more aspects of the subject disclosure include a non-transitory machine-readable medium comprising executable instructions that, when executed by a processing system including a processor, facilitate performance of operations, the operations comprising: sending, to a control plane infrastructure of a wireless network, a particular version of a set of policies, wherein the control plane infrastructure is currently using a first set of policies that differs from the particular version of the set of policies, and wherein the particular version of the set of policies is being pre-positioned for use by the control plane infrastructure at a future time; sending, to a user plane infrastructure of the wireless network, the particular version of the set of policies, wherein the user plane infrastructure is currently using a second set of policies that differs from the particular version of the set of policies, and wherein the particular version of the set of policies is being pre-positioned for use by the user plane infrastructure at the future time; and subsequent to the sending of the particular version of the set of policies to each of the control plane infrastructure and the user plane infrastructure, instructing each of the control plane infrastructure and the user plane infrastructure to begin using the particular version of the set of policies that had been sent.

[0020] One or more aspects of the subject disclosure include a method, comprising: receiving by a processing system including a processor, from a control plane infrastructure of a wireless network, a first list identifying each of a plurality of versions of a policy rule base that resides on the control

plane infrastructure; receiving by the processing system, from a user plane infrastructure of the wireless network, a second list identifying each of a plurality of versions of a policy rule base that resides on the control plane infrastructure; determining by the processing system, according to the first list and the second list, a common version of a policy rule base that resides on both the control plane infrastructure and the user plane infrastructure; sending by the processing system, to the control plane infrastructure, a first message identifying the common version; and sending by the processing system, to the user plane infrastructure, a second message identifying the common version.

[0021] Referring now to FIG. **1**, a block diagram is shown illustrating an example, non-limiting embodiment of a system **100** in accordance with various aspects described herein. For example, system **100** can facilitate in whole or in part coordinating and communicating information (such as policy rules/parameters) among a control plane, a user plane, and/or a policy charging and rules function (in one example, the policy rules/parameters can be embodied within one or more policy rule bases). In particular, a communications network **125** is presented for providing broadband access **110** to a plurality of data terminals **114** via access terminal **112**, wireless access **120** to a plurality of mobile devices **124** and vehicle **126** via base station or access point **122**, voice access **130** to a plurality of telephony devices **134**, via switching device **132** and/or media access **140** to a plurality of audio/video display devices **144** via media terminal **142**. In addition, communication network **125** is coupled to one or more content sources **175** of audio, video, graphics, text and/or other media. While broadband access **110**, wireless access **120**, voice access **130** and media access **140** are shown separately, one or more of these forms of access can be combined to provide multiple access services to a single client device (e.g., mobile devices **124** can receive media content via media terminal **142**, data terminal **114** can be provided voice access via switching device **132**, and so on).

[0022] The communications network **125** includes a plurality of network elements (NE) **150**, **152**, **154**, **156**, etc. for facilitating the broadband access **110**, wireless access **120**, voice access **130**, media access **140** and/or the distribution of content from content sources **175**. The communications network **125** can include a circuit switched or packet switched network, a voice over Internet protocol (VOIP) network, Internet protocol (IP) network, a cable network, a passive or active optical network, a 4G, 5G, or higher generation wireless access network, WIMAX network, UltraWideband network, personal area network or other wireless access network, a broadcast satellite network and/or other communications network.

[0023] In various embodiments, the access terminal **112** can include a digital subscriber line access multiplexer (DSLAM), cable modem termination system (CMTS), optical line terminal (OLT) and/or other access terminal. The data terminals **114** can include personal computers, laptop computers, netbook computers, tablets or other computing devices along with digital subscriber line (DSL) modems, data over coax service interface specification (DOCSIS) modems or other cable modems, a wireless modem such as a 4G, 5G, or higher generation modem, an optical modem and/or other access devices.

[0024] In various embodiments, the base station or access point **122** can include a 4G, 5G, or higher generation base station, an access point that operates via an 802.11 standard such as 802.11n, 802.11ac or other wireless access terminal. The mobile devices **124** can include mobile phones, e-readers, tablets, phablets, wireless modems, and/or other mobile computing devices.

[0025] In various embodiments, the switching device **132** can include a private branch exchange or central office switch, a media services gateway, VoIP gateway or other gateway device and/or other switching device. The telephony devices **134** can include traditional telephones (with or without a terminal adapter), VoIP telephones and/or other telephony devices.

[0026] In various embodiments, the media terminal **142** can include a cable head-end or other TV head-end, a satellite receiver, gateway or other media terminal **142**. The display devices **144** can include televisions with or without a set top box, personal computers and/or other display devices.

[0027] In various embodiments, the content sources **175** include broadcast television and radio sources, video on demand platforms and streaming video and audio services platforms, one or more content data networks, data servers, web servers and other content servers, and/or other sources of media.

[0028] In various embodiments, the communications network **125** can include wired, optical and/or wireless links and the network elements **150**, **152**, **154**, **156**, etc. can include service switching points, signal transfer points, service control points, network gateways, media distribution hubs, servers, firewalls, routers, edge devices, switches and other network nodes for routing and controlling communications traffic over wired, optical and wireless links as part of the Internet and other public networks as well as one or more private networks, for managing subscriber access, for billing and network management and for supporting other network functions.

[0029] Referring now to FIG. **2**A, this is a block diagram illustrating an example, non-limiting embodiment of a system **200** (that can function fully or partially within the communication network of FIG. **1**) in accordance with various aspects described herein. As seen, Policy Charging and Rules Function (PCRF) **202** has available to it a number of Policy Rule Bases. In this example, PCRF **202** has available to it three Policy Rule Bases: v1.0 (identified by call-out number **202**A), v2.0 (identified by call-out number **202**B), and v3.0 (identified by call-out number **202**C). Of course, any desired number (and/or version iterations) can be available to PCRF **202**. Further, Control Plane (CP) **204** has available to it a number of Policy Rule Bases. In this example, CP **204** has available to it two Policy Rule Bases: v2.0 (identified by call-out number **204**A), and v3.0 (identified by call-out number **204**B). Of course, any desired number (and/or version iterations) can be available to CP **204**. Further still, User Plane (UP) **206** has available to it a number of Policy Rule Bases. In this example, UP **206** has available to it two Policy Rule Bases: v1.0 (identified by call-out number **206**A), and v2.0 (identified by call-out number **206**B). Of course, any desired number (and/or version iterations) can be available to UP **206**.

[0030] Still referring to FIG. **2**A, in various embodiments, PCRF **202** can be implemented by one or more first servers (not shown), CP **204** can be implemented by one or more second servers (not shown), and UP **206** can be implemented by one or more third servers (not shown). In one embodiment each of the first server(s), the second server(s), and the third server(s) can be distinct from one another. In another embodiment one or more of the first server(s), the second server(s), and the third server(s) can be a common server. Further, a Policy Rule Base being available to PCRF **202** (as described above) can mean that such a Policy Rule Base is located on the first server(s) and/or is otherwise accessible (e.g., for reading and/or writing operations) to the first server(s). Such otherwise accessible can include, for example, being located on one or more databases that are accessible to the first server(s). Further still, a Policy Rule Base being available to CP **204** (as described above) can mean that such a Policy Rule Base is located on the second server(s) and/or is otherwise accessible (e.g., for reading and/or writing operations) to the second server(s). Such otherwise accessible can include, for example, being located on one or more databases that are accessible to the second server(s). Further still, a Policy Rule Base being available to UP **206** (as described above) can mean that such a Policy Rule Base is located on the third server(s) and/or is otherwise accessible (e.g., for reading and/or writing operations) to the third server(s). Such otherwise accessible can include, for example, being located on one or more databases that are accessible to the third server(s).

[0031] Still referring to FIG. **2**A, in one embodiment each of PCRF **202**, CP **204** and UP **206** can be instructed to use a common Policy Rule Base (in the example shown here, each of PCRF **202**, CP **204** and UP **206** has been instructed to use v2.0 of the Policy Rule Base (that is, element **202**B, **204**A, and **206**B)). Other operations described herein can also (or instead) be implemented (e.g., rolling back to a previous version, rolling forward to a next version at a future time). In one embodiment, respective instructions can be communicated directly to each of PCRF **202**, CP **204** and UP **206** from another element (not shown) such as one or more server(s). In one embodiment,

the instructions to one or more of PCRF **202**, CP **204** and UP **206** can be relayed by one or more of PCRF **202**, CP **204** and UP **206** from another element (not shown) such as one or more server(s) to one or more of PCRF **202**, CP **204** and UP **206**. In one embodiment, the instructions to one or more of PCRF **202**, CP **204** and UP **206** can be originated by one or more of PCRF **202**, CP **204** and UP **206**. In one embodiment, the PCRF **202** acts as the element that coordinates policy rule base usage for both the CP **204** and the UP **206**.

[0032] Referring now to FIG. **2**B, various steps of a method **2000** according to an embodiment are shown. As seen in this FIG. **2**B, step **2002** comprises obtaining first information identifying each version of a policy rule base to which a control plane architecture of a wireless network has access. Next, step **2004** comprises obtaining second information identifying each version of a policy rule base to which a user plane architecture of the wireless network has access. Next, step **2006** comprises selecting as a selected version a common version of a policy rule base to which each of the control plane architecture and the user plane architecture has access. Next, step **2008** comprises communicating an identification of the selected version to each of the control plane architecture and the user plane architecture.

[0033] While for purposes of simplicity of explanation, the respective processes are shown and described as a series of blocks in FIG. **2**B, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the blocks, as some blocks may occur in different orders and/or concurrently with other blocks from what is depicted and described herein. Moreover, not all illustrated blocks may be required to implement the methods described herein.

[0034] Referring now to FIG. **2**C, various steps of a method **2100** according to an embodiment are shown. As seen in this FIG. **2**C, step **2102** comprises sending, to a control plane infrastructure of a wireless network, a particular version of a set of policies, wherein the control plane infrastructure is currently using a first set of policies that differs from the particular version of the set of policies, and wherein the particular version of the set of policies is being pre-positioned for use by the control plane infrastructure at a future time. Next, step **2104** comprises sending, to a user plane infrastructure of the wireless network, the particular version of the set of policies, wherein the user plane infrastructure is currently using a second set of policies that differs from the particular version of the set of policies, and wherein the particular version of the set of policies is being pre-positioned for use by the user plane infrastructure at the future time. Next, step **2106** comprises subsequent to the sending of the particular version of the set of policies to each of the control plane infrastructure and the user plane infrastructure, instructing each of the control plane infrastructure and the user plane infrastructure to begin using the particular version of the set of policies that had been sent.

[0035] In one embodiment, the coordinating systems could use a particular set of policies (e.g., policy group "A") for some subscribers and the same particular set of policies (that is, policy group "A") for other subscribers. In another embodiment, the coordinating systems could use a particular set of policies (e.g., policy group "A") for some subscribers and a different particular set of policies (that is, policy group "B") for other (different) subscribers.

[0036] While for purposes of simplicity of explanation, the respective processes are shown and described as a series of blocks in FIG. **2**C, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the blocks, as some blocks may occur in different orders and/or concurrently with other blocks from what is depicted and described herein. Moreover, not all illustrated blocks may be required to implement the methods described herein.

[0037] Referring now to FIG. **2**D, various steps of a method **2200** according to an embodiment are shown. As seen in this FIG. **2**D, step **2202** comprises receiving by a processing system including a processor, from a control plane infrastructure of a wireless network, a first list identifying each of a plurality of versions of a policy rule base that resides on the control plane infrastructure. Next, step **2204** comprises receiving by the processing system, from a user plane infrastructure of the wireless network, a second list identifying each of a plurality of versions of a policy rule base that resides on

the control plane infrastructure. Next, step **2206** comprises determining by the processing system, according to the first list and the second list, a common version of a policy rule base that resides on both the control plane infrastructure and the user plane infrastructure. Next, step **2208** comprises sending by the processing system, to the control plane infrastructure, a first message identifying the common version. Next, step **2210** comprises sending by the processing system, to the user plane infrastructure, a second message identifying the common version.

[0038] While for purposes of simplicity of explanation, the respective processes are shown and described as a series of blocks in FIG. **2**D, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the blocks, as some blocks may occur in different orders and/or concurrently with other blocks from what is depicted and described herein. Moreover, not all illustrated blocks may be required to implement the methods described herein.

[0039] In one embodiment, there exists more than one common version of the policy rule base to which each of the control plane architecture, the user plane architecture, and the policy charging and rules function architecture have access. In one example, the selecting further comprises selecting as the selected version a single common version of the policy rule base to which each of the control plane architecture, the user plane architecture, and the policy charging and rules function architecture have access. In one example, the selecting is based upon an age characteristic of the single common version. In one example, the selecting is based upon the single common version being a newest common version. In one example, the selecting is based upon the single common version having a highest version number.

[0040] As described herein, various embodiments can provide for control plane user plane (CUPS) capabilities exchange (e.g., for the purpose of policy profile application).

[0041] As described herein, various embodiments can provide for improvements in operational efficiency (e.g., the ease in which upgrades can be performed; the allowing for the applications of policies independently; the ability to upgrade once all affected parties to have the correct version). Various conventional mechanisms do not provide such operational efficiencies due to certain conventional requirements to perform various configurations and/or because under certain conventional mechanisms multiple policy rule bases are not supported. Various embodiments can also provide efficiency gains as far as the ability to perform upgrades without the need to offline application of configurations to avoid the negative consequences of dissimilar policies among PCEF/PCRF or other policy affected elements. In this regard, it is noted that using certain conventional mechanisms, one would have to evacuate an entire infrastructure location's capacity to perform a policy upgrade across elements to avoid potential negative outcomes. This means the provider (using such conventional mechanisms) would need to have additional surplus capacity within a market or region to perform upgrades. In contrast, with the ability to deploy rule bases and later coordinate their application via a capabilities exchange (according to various embodiments), the need to evacuate the subscribers to perform an upgrade is removed.

[0042] As described herein, various embodiments can provide for policy rule bases that are versioned (in contrast, via certain conventional mechanisms, policy rule bases are not versioned and it is the operators' responsibility to ensure (without use of such versioned rule bases) compatible configuration across user plane and control plane.

[0043] As described herein, various embodiments can support multiple policies by a CP and/or a UP for the purposes of alignment, upgrades, and/or rollbacks. This exchange of policy capabilities (according to various embodiments) can support a cutover of subscriber sessions in-service (thus compressing the time necessary to distribute new mobile packet core policies into the network). Concurrent support (according to various embodiments) for multiple CUPS elements of different policy releases can allow for more efficient usage of available CP capacity. According to various embodiments, policy updated into the network for features and/or services can be deployed alongside current active policies for the purposes of cutovers.

[0044] As described herein, various embodiments can provide for changes (e.g., upgrades) to a

plurality of policy bases via a parallel process.

[0045] As described herein, various embodiments can operate in the context of a mobile carrier using a CUPS architecture with evolving subscriber configurations and/or policies. The same coordinating behavior, since it involves logical groups of elements and configurations, can be applied to 5G and beyond. This logical overlay (according to various embodiments) can enable an application configuration pipeline to be distributed and used for the purposes of upgrades and/or rollbacks.

[0046] As described herein, various embodiments can support (e.g., through a capabilities exchange that shares logical configuration release version information) multiple concurrent configuration profiles (e.g., for the purpose of upgrades, rollbacks, and/or migrations).

[0047] As described herein, various embodiments can support aligning configurations and policy in a dynamic manner. Through the usage of profiles and associated versions, the correct configurations and/or policy can be applied to a downstream UP from a CP with confidence that the policies will align and/or that multiple concurrent versions can be supported.

[0048] As described herein, various embodiments can support capabilities exchange (e.g., for control plane/user plane versioning) that would allow for non-active policies to be deployed into the mobile packet core prior to being invoked (which can compress maintenance and in-service updates).

[0049] As described herein, various embodiments can expand the 3GPP Packet Forwarding Control Protocol (see, for example, 3GPP 29.244) to incorporate the usage of version-control details which reflect the current supported configuration profiles for CP and/or UP. During session establishment, the CP and UP can communicate (according to various embodiments) which local policy rule bases are served. During new subscriber session arrival, the logical overlay of version-specific details and associated policies can be used (according to various embodiments) between CP and UP to ensure alignment of applicable mobile packet core policies.

[0050] As described herein, a policy can control (and/or inform) as to a "rating" (such as pre-paid/post-paid, what services are billed for, what services are not billed for).

[0051] As described herein, various embodiments can facilitate mechanisms to provide a given policy to a control plane and a user plane.

[0052] As described herein, various embodiments can provide mechanisms to coordinate policy usage among a control plane, a PCRF, and a user plane (wherein all are aligned to a given policy).

[0053] As described herein, various embodiments can provide mechanisms to pre-position a policy for use in the future.

[0054] As described herein, various embodiments can provide mechanisms to facilitate fall back from one policy to another.

[0055] As described herein, various embodiments can provide mechanisms to coordinate use of policies (e.g., coordinated roll forward, coordinated roll back).

[0056] As described herein, various embodiments can provide mechanisms to check for compatibility between (or among) policies.

[0057] As described herein, various embodiments can provide mechanisms to coordinate policy usage among a control plane, a PCRF, and a user plane (wherein the coordination is performed "out-of-band").

[0058] As described herein, in various embodiments the PCRF can be the policy arbiter, the control plane can facilitate the out-of-band signaling, and the user plane can handle the user traffic.

[0059] As described herein, in various embodiments the policy rule bases can comprise command line information.

[0060] As described herein, various embodiments can provide mechanisms to facilitate reverting to a legacy policy.

[0061] As described herein, various embodiments can facilitate a coordinated roll forward and/or a coordinated roll backward.

[0062] As described herein, various embodiments can facilitate a negotiation with respect to determining a most current policy that is shared among the PCRF, CP, and UP.

[0063] As described herein, in various embodiments a given policy rule base can be identified via versioning and/or by labels.

[0064] As described herein, a billing parameter can comprise an indication of a rate plan of a subscriber, a tier of a subscriber, or any combination thereof.

[0065] As described herein, a billing parameter can be indicative of a subscriber falling within various rate or billing plans (e.g., prepaid, postpaid, enterprise, etc.) as the service provider structures or bills differentiated services. Additionally, a billing parameter can be indicative of one or more grandfathered plans (in this regard, it is noted that companies may be forced to support grandfathered plans over time). Additionally, a billing parameter can be indicative of one or more subscriber treatments (in this regard, it is noted that plans may incorporate subscriber treatments based upon usage (e.g., quota, time of day, content, policing or shaping to a rate plan, and/or differentiated speeds)).

[0066] As described herein, an operating parameter can be indicative of speed characteristics (e.g., Available Bitrate, Guaranteed Bitrate, Maximum Bitrate, QoS Class Identifier (QCI), Allocation and Retention Priority (ARP), Diffserv Code Point (DSCP), Next-Hop Route Selection, and/or Virtual Local Area Network (VLAN) tags.

[0067] As described herein, an operating parameter can be indicative of service characteristics (e.g., optimization of video traffic, scanning for viruses, and/or scanning for phishing).

[0068] Referring now to FIG. **3**, a block diagram **300** is shown illustrating an example, non-limiting embodiment of a virtualized communication network in accordance with various aspects described herein. In particular a virtualized communication network is presented that can be used to implement some or all of the subsystems and functions of system **100**, some or all of the subsystems and functions of system **200**, and/or some or all of the methods **2000**, **2100**, **2200**. For example, virtualized communication network **300** can facilitate in whole or in part coordinating and communicating information (such as policy rules/parameters) among a control plane, a user plane, and/or a policy charging and rules function (in one example, the policy rules/parameters can be embodied within one or more policy rule bases).

[0069] In particular, a cloud networking architecture is shown that leverages cloud technologies and supports rapid innovation and scalability via a transport layer **350**, a virtualized network function cloud **325** and/or one or more cloud computing environments **375**. In various embodiments, this cloud networking architecture is an open architecture that leverages application programming interfaces (APIs); reduces complexity from services and operations; supports more nimble business models; and rapidly and seamlessly scales to meet evolving customer requirements including traffic growth, diversity of traffic types, and diversity of performance and reliability expectations.

[0070] In contrast to traditional network elements—which are typically integrated to perform a single function, the virtualized communication network employs virtual network elements (VNEs) **330**, **332**, **334**, etc. that perform some or all of the functions of network elements **150**, **152**, **154**, **156**, etc. For example, the network architecture can provide a substrate of networking capability, often called Network Function Virtualization Infrastructure (NFVI) or simply infrastructure that is capable of being directed with software and Software Defined Networking (SDN) protocols to perform a broad variety of network functions and services. This infrastructure can include several types of substrates. The most typical type of substrate being servers that support Network Function Virtualization (NFV), followed by packet forwarding capabilities based on generic computing resources, with specialized network technologies brought to bear when general-purpose processors or general-purpose integrated circuit devices offered by merchants (referred to herein as merchant silicon) are not appropriate. In this case, communication services can be implemented as cloud-centric workloads.

[0071] As an example, a traditional network element **150** (shown in FIG. **1**), such as an edge router can be implemented via a VNE **330** composed of NFV software modules, merchant silicon, and associated controllers. The software can be written so that increasing workload consumes incremental resources from a common resource pool, and moreover so that it is elastic: so, the resources are only consumed when needed. In a similar fashion, other network elements such as other routers, switches, edge caches, and middle boxes are instantiated from the common resource pool. Such sharing of infrastructure across a broad set of uses makes planning and growing infrastructure easier to manage.

[0072] In an embodiment, the transport layer **350** includes fiber, cable, wired and/or wireless transport elements, network elements and interfaces to provide broadband access **110**, wireless access **120**, voice access **130**, media access **140** and/or access to content sources **175** for distribution of content to any or all of the access technologies. In particular, in some cases a network element needs to be positioned at a specific place, and this allows for less sharing of common infrastructure. Other times, the network elements have specific physical layer adapters that cannot be abstracted or virtualized and might require special DSP code and analog front ends (AFEs) that do not lend themselves to implementation as VNEs **330**, **332** or **334**. These network elements can be included in transport layer **350**.

[0073] The virtualized network function cloud **325** interfaces with the transport layer **350** to provide the VNEs **330**, **332**, **334**, etc. to provide specific NFVs. In particular, the virtualized network function cloud **325** leverages cloud operations, applications, and architectures to support networking workloads. The virtualized network elements **330**, **332** and **334** can employ network function software that provides either a one-for-one mapping of traditional network element function or alternately some combination of network functions designed for cloud computing. For example, VNEs **330**, **332** and **334** can include route reflectors, domain name system (DNS) servers, and dynamic host configuration protocol (DHCP) servers, system architecture evolution (SAE) and/or mobility management entity (MME) gateways, broadband network gateways, IP edge routers for IP-VPN, Ethernet and other services, load balancers, distributers and other network elements. Because these elements do not typically need to forward large amounts of traffic, their workload can be distributed across a number of servers-each of which adds a portion of the capability, and which creates an elastic function with higher availability overall than its former monolithic version. These virtual network elements **330**, **332**, **334**, etc. can be instantiated and managed using an orchestration approach similar to those used in cloud compute services.

[0074] The cloud computing environments **375** can interface with the virtualized network function cloud **325** via APIs that expose functional capabilities of the VNEs **330**, **332**, **334**, etc. to provide the flexible and expanded capabilities to the virtualized network function cloud **325**. In particular, network workloads may have applications distributed across the virtualized network function cloud **325** and cloud computing environment **375** and in the commercial cloud or might simply orchestrate workloads supported entirely in NFV infrastructure from these third-party locations.

[0075] Turning now to FIG. **4**, there is illustrated a block diagram of a computing environment in accordance with various aspects described herein. In order to provide additional context for various embodiments of the embodiments described herein, FIG. **4** and the following discussion are intended to provide a brief, general description of a suitable computing environment **400** in which the various embodiments of the subject disclosure can be implemented. In particular, computing environment **400** can be used in the implementation of network elements **150**, **152**, **154**, **156**, access terminal **112**, base station or access point **122**, switching device **132**, media terminal **142**, and/or VNEs **330**, **332**, **334**, etc. Each of these devices can be implemented via computer-executable instructions that can run on one or more computers, and/or in combination with other program modules and/or as a combination of hardware and software. For example, computing environment **400** can facilitate in whole or in part coordinating and communicating information (such as policy rules/parameters) among a control plane, a user plane, and/or a policy charging and

rules function (in one example, the policy rules/parameters can be embodied within one or more policy rule bases).

[0076] Generally, program modules comprise routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the methods can be practiced with other computer system configurations, comprising single-processor or multiprocessor computer systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

[0077] As used herein, a processing circuit includes one or more processors as well as other application specific circuits such as an application specific integrated circuit, digital logic circuit, state machine, programmable gate array or other circuit that processes input signals or data and that produces output signals or data in response thereto. It should be noted that while any functions and features described herein in association with the operation of a processor could likewise be performed by a processing circuit.

[0078] The illustrated embodiments of the embodiments herein can be also practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

[0079] Computing devices typically comprise a variety of media, which can comprise computer-readable storage media and/or communications media, which two terms are used herein differently from one another as follows. Computer-readable storage media can be any available storage media that can be accessed by the computer and comprises both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable instructions, program modules, structured data or unstructured data.

[0080] Computer-readable storage media can comprise, but are not limited to, random access memory (RAM), read only memory (ROM), electrically erasable programmable read only memory (EEPROM),flash memory or other memory technology, compact disk read only memory (CD-ROM), digital versatile disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices or other tangible and/or non-transitory media which can be used to store desired information. In this regard, the terms "tangible" or "non-transitory" herein as applied to storage, memory or computer-readable media, are to be understood to exclude only propagating transitory signals per se as modifiers and do not relinquish rights to all standard storage, memory or computer-readable media that are not only propagating transitory signals per se.

[0081] Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

[0082] Communications media typically embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and comprises any information delivery or transport media. The term "modulated data signal" or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communication media comprise wired media, such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media.

[0083] With reference again to FIG. **4**, the example environment can comprise a computer **402**, the computer **402** comprising a processing unit **404**, a system memory **406** and a system bus **408**. The

system bus **408** couples system components including, but not limited to, the system memory **406** to the processing unit **404**. The processing unit **404** can be any of various commercially available processors. Dual microprocessors and other multiprocessor architectures can also be employed as the processing unit **404**.

[0084] The system bus **408** can be any of several types of bus structure that can further interconnect to a memory bus (with or without a memory controller), a peripheral bus, and a local bus using any of a variety of commercially available bus architectures. The system memory **406** comprises ROM **410** and RAM **412**. A basic input/output system (BIOS) can be stored in a non-volatile memory such as ROM, erasable programmable read only memory (EPROM), EEPROM, which BIOS contains the basic routines that help to transfer information between elements within the computer **402**, such as during startup. The RAM **412** can also comprise a high-speed RAM such as static RAM for caching data.

[0085] The computer **402** further comprises an internal hard disk drive (HDD) **414** (e.g., EIDE, SATA), which internal HDD **414** can also be configured for external use in a suitable chassis (not shown), a magnetic floppy disk drive (FDD) **416**, (e.g., to read from or write to a removable diskette **418**) and an optical disk drive **420**, (e.g., reading a CD-ROM disk **422** or, to read from or write to other high-capacity optical media such as the DVD). The HDD **414**, magnetic FDD **416** and optical disk drive **420** can be connected to the system bus **408** by a hard disk drive interface **424**, a magnetic disk drive interface **426** and an optical drive interface **428**, respectively. The hard disk drive interface **424** for external drive implementations comprises at least one or both of Universal Serial Bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) 1394 interface technologies. Other external drive connection technologies are within contemplation of the embodiments described herein.

[0086] The drives and their associated computer-readable storage media provide nonvolatile storage of data, data structures, computer-executable instructions, and so forth. For the computer **402**, the drives and storage media accommodate the storage of any data in a suitable digital format. Although the description of computer-readable storage media above refers to a hard disk drive (HDD), a removable magnetic diskette, and a removable optical media such as a CD or DVD, it should be appreciated by those skilled in the art that other types of storage media which are readable by a computer, such as zip drives, magnetic cassettes, flash memory cards, cartridges, and the like, can also be used in the example operating environment, and further, that any such storage media can contain computer-executable instructions for performing the methods described herein.

[0087] A number of program modules can be stored in the drives and RAM **412**, comprising an operating system **430**, one or more application programs **432**, other program modules **434** and program data **436**. All or portions of the operating system, applications, modules, and/or data can also be cached in the RAM **412**. The systems and methods described herein can be implemented utilizing various commercially available operating systems or combinations of operating systems.

[0088] A user can enter commands and information into the computer **402** through one or more wired/wireless input devices, e.g., a keyboard **438** and a pointing device, such as a mouse **440**. Other input devices (not shown) can comprise a microphone, an infrared (IR) remote control, a joystick, a game pad, a stylus pen, touch screen or the like. These and other input devices are often connected to the processing unit **404** through an input device interface **442** that can be coupled to the system bus **408**, but can be connected by other interfaces, such as a parallel port, an IEEE 1394 serial port, a game port, a universal serial bus (USB) port, an IR interface, etc.

[0089] A monitor **444** or other type of display device can be also connected to the system bus **408** via an interface, such as a video adapter **446**. It will also be appreciated that in alternative embodiments, a monitor **444** can also be any display device (e.g., another computer having a display, a smart phone, a tablet computer, etc.) for receiving display information associated with computer **402** via any communication means, including via the Internet and cloud-based networks. In addition to the monitor **444**, a computer typically comprises other peripheral output devices (not

shown), such as speakers, printers, etc.

[0090] The computer **402** can operate in a networked environment using logical connections via wired and/or wireless communications to one or more remote computers, such as a remote computer(s) **448**. The remote computer(s) **448** can be a workstation, a server computer, a router, a personal computer, portable computer, microprocessor-based entertainment appliance, a peer device or other common network node, and typically comprises many or all of the elements described relative to the computer **402**, although, for purposes of brevity, only a remote memory/storage device **450** is illustrated. The logical connections depicted comprise wired/wireless connectivity to a local area network (LAN) **452** and/or larger networks, e.g., a wide area network (WAN) **454**. Such LAN and WAN networking environments are commonplace in offices and companies, and facilitate enterprise-wide computer networks, such as intranets, all of which can connect to a global communications network, e.g., the Internet.

[0091] When used in a LAN networking environment, the computer **402** can be connected to the LAN **452** through a wired and/or wireless communication network interface or adapter **456**. The adapter **456** can facilitate wired or wireless communication to the LAN **452**, which can also comprise a wireless AP disposed thereon for communicating with the adapter **456**.

[0092] When used in a WAN networking environment, the computer **402** can comprise a modem **458** or can be connected to a communications server on the WAN **454** or has other means for establishing communications over the WAN **454**, such as by way of the Internet. The modem **458**, which can be internal or external and a wired or wireless device, can be connected to the system bus **408** via the input device interface **442**. In a networked environment, program modules depicted relative to the computer **402** or portions thereof, can be stored in the remote memory/storage device **450**. It will be appreciated that the network connections shown are example and other means of establishing a communications link between the computers can be used.

[0093] The computer **402** can be operable to communicate with any wireless devices or entities operatively disposed in wireless communication, e.g., a printer, scanner, desktop and/or portable computer, portable data assistant, communications satellite, any piece of equipment or location associated with a wirelessly detectable tag (e.g., a kiosk, news stand, restroom), and telephone. This can comprise Wireless Fidelity (Wi-Fi) and BLUETOOTH® wireless technologies. Thus, the communication can be a predefined structure as with a conventional network or simply an ad hoc communication between at least two devices.

[0094] Wi-Fi can allow connection to the Internet from a couch at home, a bed in a hotel room or a conference room at work, without wires. Wi-Fi is a wireless technology similar to that used in a cell phone that enables such devices, e.g., computers, to send and receive data indoors and out; anywhere within the range of a base station. Wi-Fi networks use radio technologies called IEEE 802.11 (a, b, g, n, ac, ag, etc.) to provide secure, reliable, fast wireless connectivity. A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wired networks (which can use IEEE 802.3 or Ethernet). Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands for example or with products that contain both bands (dual band), so the networks can provide real-world performance similar to the basic 10BaseT wired Ethernet networks used in many offices.

[0095] Turning now to FIG. **5**, an embodiment **500** of a mobile network platform **510** is shown that is an example of network elements **150**, **152**, **154**, **156**, and/or VNEs **330**, **332**, **334**, etc. For example, platform **510** can facilitate in whole or in part coordinating and communicating information (such as policy rules/parameters) among a control plane, a user plane, and/or a policy charging and rules function (in one example, the policy rules/parameters can be embodied within one or more policy rule bases). In one or more embodiments, the mobile network platform **510** can generate and receive signals transmitted and received by base stations or access points such as base station or access point **122**. Generally, mobile network platform **510** can comprise components, e.g., nodes, gateways, interfaces, servers, or disparate platforms, that facilitate both packet-

switched (PS) (e.g., internet protocol (IP), frame relay, asynchronous transfer mode (ATM)) and circuit-switched (CS) traffic (e.g., voice and data), as well as control generation for networked wireless telecommunication. As a non-limiting example, mobile network platform **510** can be included in telecommunications carrier networks and can be considered carrier-side components as discussed elsewhere herein. Mobile network platform **510** comprises CS gateway node(s) **512** which can interface CS traffic received from legacy networks like telephony network(s) **540** (e.g., public switched telephone network (PSTN), or public land mobile network (PLMN)) or a signaling system #7 (SS7) network **560**. CS gateway node(s) **512** can authorize and authenticate traffic (e.g., voice) arising from such networks. Additionally, CS gateway node(s) **512** can access mobility, or roaming, data generated through SS7 network **560**; for instance, mobility data stored in a visited location register (VLR), which can reside in memory **530**. Moreover, CS gateway node(s) **512** interfaces CS-based traffic and signaling and PS gateway node(s) **518**. As an example, in a 3GPP UMTS network, CS gateway node(s) **512** can be realized at least in part in gateway GPRS support node(s) (GGSN). It should be appreciated that functionality and specific operation of CS gateway node(s) **512**, PS gateway node(s) **518**, and serving node(s) **516**, is provided and dictated by radio technology(ies) utilized by mobile network platform **510** for telecommunication over a radio access network **520** with other devices, such as a radiotelephone **575**.

[0096] In addition to receiving and processing CS-switched traffic and signaling, PS gateway node(s) **518** can authorize and authenticate PS-based data sessions with served mobile devices. Data sessions can comprise traffic, or content(s), exchanged with networks external to the mobile network platform **510**, like wide area network(s) (WANs) **550**, enterprise network(s) **570**, and service network(s) **580**, which can be embodied in local area network(s) (LANs), can also be interfaced with mobile network platform **510** through PS gateway node(s) **518**. It is to be noted that WANs **550** and enterprise network(s) **570** can embody, at least in part, a service network(s) like IP multimedia subsystem (IMS). Based on radio technology layer(s) available in technology resource(s) or radio access network **520**, PS gateway node(s) **518** can generate packet data protocol contexts when a data session is established; other data structures that facilitate routing of packetized data also can be generated. To that end, in an aspect, PS gateway node(s) **518** can comprise a tunnel interface (e.g., tunnel termination gateway (TTG) in 3GPP UMTS network(s) (not shown)) which can facilitate packetized communication with disparate wireless network(s), such as Wi-Fi networks.

[0097] In embodiment **500**, mobile network platform **510** also comprises serving node(s) **516** that, based upon available radio technology layer(s) within technology resource(s) in the radio access network **520**, convey the various packetized flows of data streams received through PS gateway node(s) **518**. It is to be noted that for technology resource(s) that rely primarily on CS communication, server node(s) can deliver traffic without reliance on PS gateway node(s) **518**; for example, server node(s) can embody at least in part a mobile switching center. As an example, in a 3GPP UMTS network, serving node(s) **516** can be embodied in serving GPRS support node(s) (SGSN).

[0098] For radio technologies that exploit packetized communication, server(s) **514** in mobile network platform **510** can execute numerous applications that can generate multiple disparate packetized data streams or flows, and manage (e.g., schedule, queue, format . . .) such flows. Such application(s) can comprise add-on features to standard services (for example, provisioning, billing, customer support . . .) provided by mobile network platform **510**. Data streams (e.g., content(s) that are part of a voice call or data session) can be conveyed to PS gateway node(s) **518** for authorization/authentication and initiation of a data session, and to serving node(s) **516** for communication thereafter. In addition to application server, server(s) **514** can comprise utility server(s), a utility server can comprise a provisioning server, an operations and maintenance server, a security server that can implement at least in part a certificate authority and firewalls as well as other security mechanisms, and the like. In an aspect, security server(s) secure communication

served through mobile network platform **510** to ensure network's operation and data integrity in addition to authorization and authentication procedures that CS gateway node(s) **512** and PS gateway node(s) **518** can enact. Moreover, provisioning server(s) can provision services from external network(s) like networks operated by a disparate service provider; for instance, WAN **550** or Global Positioning System (GPS) network(s) (not shown). Provisioning server(s) can also provision coverage through networks associated to mobile network platform **510** (e.g., deployed and operated by the same service provider), such as the distributed antennas networks shown in FIG. **1**(*s*) that enhance wireless service coverage by providing more network coverage.

[0099] It is to be noted that server(s) **514** can comprise one or more processors configured to confer at least in part the functionality of mobile network platform **510**. To that end, the one or more processors can execute code instructions stored in memory **530**, for example. It should be appreciated that server(s) **514** can comprise a content manager, which operates in substantially the same manner as described hereinbefore.

[0100] In example embodiment **500**, memory **530** can store information related to operation of mobile network platform **510**. Other operational information can comprise provisioning information of mobile devices served through mobile network platform **510**, subscriber databases; application intelligence, pricing schemes, e.g., promotional rates, flat-rate programs, couponing campaigns; technical specification(s) consistent with telecommunication protocols for operation of disparate radio, or wireless, technology layers; and so forth. Memory **530** can also store information from at least one of telephony network(s) **540**, WAN **550**, SS7 network **560**, or enterprise network(s) **570**. In an aspect, memory **530** can be, for example, accessed as part of a data store component or as a remotely connected memory store.

[0101] In order to provide a context for the various aspects of the disclosed subject matter, FIG. **5**, and the following discussion, are intended to provide a brief, general description of a suitable environment in which the various aspects of the disclosed subject matter can be implemented. While the subject matter has been described above in the general context of computer-executable instructions of a computer program that runs on a computer and/or computers, those skilled in the art will recognize that the disclosed subject matter also can be implemented in combination with other program modules. Generally, program modules comprise routines, programs, components, data structures, etc. that perform particular tasks and/or implement particular abstract data types.

[0102] Turning now to FIG. **6**, an illustrative embodiment of a communication device **600** is shown. The communication device **600** can serve as an illustrative embodiment of devices such as data terminals **114**, mobile devices **124**, vehicle **126**, display devices **144** or other client devices for communication via either communications network **125**. For example, computing device **600** can facilitate in whole or in part coordinating and communicating information (such as policy rules/parameters) among a control plane, a user plane, and/or a policy charging and rules function (in one example, the policy rules/parameters can be embodied within one or more policy rule bases).

[0103] The communication device **600** can comprise a wireline and/or wireless transceiver **602** (herein transceiver **602**), a user interface (UI) **604**, a power supply **614**, a location receiver **616**, a motion sensor **618**, an orientation sensor **620**, and a controller **606** for managing operations thereof. The transceiver **602** can support short-range or long-range wireless access technologies such as Bluetooth®, ZigBee®, Wi-Fi, DECT, or cellular communication technologies, just to mention a few (Bluetooth® and ZigBee® are trademarks registered by the Bluetooth® Special Interest Group and the ZigBee® Alliance, respectively). Cellular technologies can include, for example, CDMA-1X, UMTS/HSDPA, GSM/GPRS, TDMA/EDGE, EV/DO, WiMAX, SDR, LTE, as well as other next generation wireless communication technologies as they arise. The transceiver **602** can also be adapted to support circuit-switched wireline access technologies (such as PSTN), packet-switched wireline access technologies (such as TCP/IP, VOIP, etc.), and combinations thereof.

[0104] The UI **604** can include a depressible or touch-sensitive keypad **608** with a navigation

mechanism such as a roller ball, a joystick, a mouse, or a navigation disk for manipulating operations of the communication device **600**. The keypad **608** can be an integral part of a housing assembly of the communication device **600** or an independent device operably coupled thereto by a tethered wireline interface (such as a USB cable) or a wireless interface supporting for example Bluetooth®. The keypad **608** can represent a numeric keypad commonly used by phones, and/or a QWERTY keypad with alphanumeric keys. The UI **604** can further include a display **610** such as monochrome or color LCD (Liquid Crystal Display), OLED (Organic Light Emitting Diode) or other suitable display technology for conveying images to an end user of the communication device **600**. In an embodiment where the display **610** is touch-sensitive, a portion or all of the keypad **608** can be presented by way of the display **610** with navigation features.

[0105] The display **610** can use touch screen technology to also serve as a user interface for detecting user input. As a touch screen display, the communication device **600** can be adapted to present a user interface having graphical user interface (GUI) elements that can be selected by a user with a touch of a finger. The display **610** can be equipped with capacitive, resistive or other forms of sensing technology to detect how much surface area of a user's finger has been placed on a portion of the touch screen display. This sensing information can be used to control the manipulation of the GUI elements or other functions of the user interface. The display **610** can be an integral part of the housing assembly of the communication device **600** or an independent device communicatively coupled thereto by a tethered wireline interface (such as a cable) or a wireless interface.

[0106] The UI **604** can also include an audio system **612** that utilizes audio technology for conveying low volume audio (such as audio heard in proximity of a human ear) and high-volume audio (such as speakerphone for hands free operation). The audio system **612** can further include a microphone for receiving audible signals of an end user. The audio system **612** can also be used for voice recognition applications. The UI **604** can further include an image sensor **613** such as a charged coupled device (CCD) camera for capturing still or moving images.

[0107] The power supply **614** can utilize common power management technologies such as replaceable and rechargeable batteries, supply regulation technologies, and/or charging system technologies for supplying energy to the components of the communication device **600** to facilitate long-range or short-range portable communications. Alternatively, or in combination, the charging system can utilize external power sources such as DC power supplied over a physical interface such as a USB port or other suitable tethering technologies.

[0108] The location receiver **616** can utilize location technology such as a global positioning system (GPS) receiver capable of assisted GPS for identifying a location of the communication device **600** based on signals generated by a constellation of GPS satellites, which can be used for facilitating location services such as navigation. The motion sensor **618** can utilize motion sensing technology such as an accelerometer, a gyroscope, or other suitable motion sensing technology to detect motion of the communication device **600** in three-dimensional space. The orientation sensor **620** can utilize orientation sensing technology such as a magnetometer to detect the orientation of the communication device **600** (north, south, west, and east, as well as combined orientations in degrees, minutes, or other suitable orientation metrics).

[0109] The communication device **600** can use the transceiver **602** to also determine a proximity to a cellular, Wi-Fi, Bluetooth®, or other wireless access points by sensing techniques such as utilizing a received signal strength indicator (RSSI) and/or signal time of arrival (TOA) or time of flight (TOF) measurements. The controller **606** can utilize computing technologies such as a microprocessor, a digital signal processor (DSP), programmable gate arrays, application specific integrated circuits, and/or a video processor with associated storage memory such as Flash, ROM, RAM, SRAM, DRAM or other storage technologies for executing computer instructions, controlling, and processing data supplied by the aforementioned components of the communication device **600**.

[0110] Other components not shown in FIG. **6** can be used in one or more embodiments of the subject disclosure. For instance, the communication device **600** can include a slot for adding or removing an identity module such as a Subscriber Identity Module (SIM) card or Universal Integrated Circuit Card (UICC). SIM or UICC cards can be used for identifying subscriber services, executing programs, storing subscriber data, and so on.

[0111] The terms "first," "second," "third," and so forth, as used in the claims, unless otherwise clear by context, is for clarity only and does not otherwise indicate or imply any order in time. For instance, "a first determination," "a second determination," and "a third determination," does not indicate or imply that the first determination is to be made before the second determination, or vice versa, etc.

[0112] In the subject specification, terms such as "store," "storage," "data store," data storage," "database," and substantially any other information storage component relevant to operation and functionality of a component, refer to "memory components," or entities embodied in a "memory" or components comprising the memory. It will be appreciated that the memory components described herein can be either volatile memory or nonvolatile memory, or can comprise both volatile and nonvolatile memory, by way of illustration, and not limitation, volatile memory, non-volatile memory, disk storage, and memory storage. Further, nonvolatile memory can be included in read only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable ROM (EEPROM), or flash memory. Volatile memory can comprise random access memory (RAM), which acts as external cache memory. By way of illustration and not limitation, RAM is available in many forms such as synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM). Additionally, the disclosed memory components of systems or methods herein are intended to comprise, without being limited to comprising, these and any other suitable types of memory.

[0113] Moreover, it will be noted that the disclosed subject matter can be practiced with other computer system configurations, comprising single-processor or multiprocessor computer systems, mini-computing devices, mainframe computers, as well as personal computers, hand-held computing devices (e.g., PDA, phone, smartphone, watch, tablet computers, netbook computers, etc.), microprocessor-based or programmable consumer or industrial electronics, and the like. The illustrated aspects can also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network; however, some if not all aspects of the subject disclosure can be practiced on stand-alone computers. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

[0114] In one or more embodiments, information regarding use of services can be generated including services being accessed, media consumption history, user preferences, and so forth. This information can be obtained by various methods including user input, detecting types of communications (e.g., video content vs. audio content), analysis of content streams, sampling, and so forth. The generating, obtaining and/or monitoring of this information can be responsive to an authorization provided by the user. In one or more embodiments, an analysis of data can be subject to authorization from user(s) associated with the data, such as an opt-in, an opt-out, acknowledgement requirements, notifications, selective authorization based on types of data, and so forth.

[0115] Some of the embodiments described herein can also employ artificial intelligence (AI) to facilitate automating one or more features described herein. The embodiments (e.g., in connection with automatically coordinating and communicating information (such as policy rules/parameters) among a control plane, a user plane, and/or a policy charging and rules function) can employ various AI-based schemes for carrying out various embodiments thereof. Moreover, the classifier

can be employed to determine a ranking or priority of each policy, rule, control plane, user plane, and/or policy charging and rules function. A classifier is a function that maps an input attribute vector, x=(x.sub.1, x.sub.2, x.sub.3, x.sub.4. . . . x.sub.n), to a confidence that the input belongs to a class, that is, f(x)=confidence (class). Such classification can employ a probabilistic and/or statistical-based analysis (e.g., factoring into the analysis utilities and costs) to determine or infer an action that a user desires to be automatically performed. A support vector machine (SVM) is an example of a classifier that can be employed. The SVM operates by finding a hypersurface in the space of possible inputs, which the hypersurface attempts to split the triggering criteria from the non-triggering events. Intuitively, this makes the classification correct for testing data that is near, but not identical to training data. Other directed and undirected model classification approaches comprise, e.g., naïve Bayes, Bayesian networks, decision trees, neural networks, fuzzy logic models, and probabilistic classification models providing different patterns of independence can be employed. Classification as used herein also is inclusive of statistical regression that is utilized to develop models of priority.

[0116] As will be readily appreciated, one or more of the embodiments can employ classifiers that are explicitly trained (e.g., via a generic training data) as well as implicitly trained (e.g., via observing UE behavior, operator preferences, historical information, receiving extrinsic information). For example, SVMs can be configured via a learning or training phase within a classifier constructor and feature selection module. Thus, the classifier(s) can be used to automatically learn and perform a number of functions, including but not limited to determining according to predetermined criteria which of the policies, rules, control planes, user planes, and/or policy charging and rules functions will receive priority.

[0117] As used in some contexts in this application, in some embodiments, the terms "component," "system" and the like are intended to refer to, or comprise, a computer-related entity or an entity related to an operational apparatus with one or more specific functionalities, wherein the entity can be either hardware, a combination of hardware and software, software, or software in execution. As an example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, computer-executable instructions, a program, and/or a computer. By way of illustration and not limitation, both an application running on a server and the server can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers. In addition, these components can execute from various computer readable media having various data structures stored thereon. The components may communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems via the signal). As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry, which is operated by a software or firmware application executed by a processor, wherein the processor can be internal or external to the apparatus and executes at least a part of the software or firmware application. As yet another example, a component can be an apparatus that provides specific functionality through electronic components without mechanical parts, the electronic components can comprise a processor therein to execute software or firmware that confers at least in part the functionality of the electronic components. While various components have been illustrated as separate components, it will be appreciated that multiple components can be implemented as a single component, or a single component can be implemented as multiple components, without departing from example embodiments.

[0118] Further, the various embodiments can be implemented as a method, apparatus or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware or any combination thereof to control a computer to implement the disclosed

subject matter. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device or computer-readable storage/communications media. For example, computer readable storage media can include, but are not limited to, magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips), optical disks (e.g., compact disk (CD), digital versatile disk (DVD)), smart cards, and flash memory devices (e.g., card, stick, key drive). Of course, those skilled in the art will recognize many modifications can be made to this configuration without departing from the scope or spirit of the various embodiments.

[0119] In addition, the words "example" and "exemplary" are used herein to mean serving as an instance or illustration. Any embodiment or design described herein as "example" or "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments or designs. Rather, use of the word example or exemplary is intended to present concepts in a concrete fashion. As used in this application, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or". That is, unless specified otherwise or clear from context, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then "X employs A or B" is satisfied under any of the foregoing instances.

[0120] In addition, the articles "a" and "an" as used in this application and the appended claims should generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form.

[0121] Moreover, terms such as "user equipment," "mobile station," "mobile," subscriber station," "access terminal," "terminal," "handset," "mobile device" (and/or terms representing similar terminology) can refer to a wireless device utilized by a subscriber or user of a wireless communication service to receive or convey data, control, voice, video, sound, gaming or substantially any data-stream or signaling-stream. The foregoing terms are utilized interchangeably herein and with reference to the related drawings.

[0122] Furthermore, the terms "user," "subscriber," "customer," "consumer" and the like are employed interchangeably throughout, unless context warrants particular distinctions among the terms. It should be appreciated that such terms can refer to human entities or automated components supported through artificial intelligence (e.g., a capacity to make inference based, at least, on complex mathematical formalisms), which can provide simulated vision, sound recognition and so forth.

[0123] As employed herein, the term "processor" can refer to substantially any computing processing unit or device comprising, but not limited to comprising, single-core processors; single-processors with software multithread execution capability; multi-core processors; multi-core processors with software multithread execution capability; multi-core processors with hardware multithread technology; parallel platforms; and parallel platforms with distributed shared memory. Additionally, a processor can refer to an integrated circuit, an application specific integrated circuit (ASIC), a digital signal processor (DSP), a field programmable gate array (FPGA), a programmable logic controller (PLC), a complex programmable logic device (CPLD), a discrete gate or transistor logic, discrete hardware components or any combination thereof designed to perform the functions described herein. Processors can exploit nano-scale architectures such as, but not limited to, molecular and quantum-dot based transistors, switches and gates, in order to optimize space usage or enhance performance of user equipment. A processor can also be implemented as a combination of computing processing units.

[0124] As used herein, terms such as "data storage," data storage," "database," and substantially any other information storage component relevant to operation and functionality of a component, refer to "memory components," or entities embodied in a "memory" or components comprising the memory. It will be appreciated that the memory components or computer-readable storage media, described herein can be either volatile memory or nonvolatile memory or can include both volatile

and nonvolatile memory.

[0125] What has been described above includes mere examples of various embodiments. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing these examples, but one of ordinary skill in the art can recognize that many further combinations and permutations of the present embodiments are possible. Accordingly, the embodiments disclosed and/or claimed herein are intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

[0126] In addition, a flow diagram may include a "start" and/or "continue" indication. The "start" and "continue" indications reflect that the steps presented can optionally be incorporated in or otherwise used in conjunction with other routines. In this context, "start" indicates the beginning of the first step presented and may be preceded by other activities not specifically shown. Further, the "continue" indication reflects that the steps presented may be performed multiple times and/or may be succeeded by other activities not specifically shown. Further, while a flow diagram indicates a particular ordering of steps, other orderings are likewise possible provided that the principles of causality are maintained.

[0127] As may also be used herein, the term(s) "operably coupled to", "coupled to", and/or "coupling" includes direct coupling between items and/or indirect coupling between items via one or more intervening items. Such items and intervening items include, but are not limited to, junctions, communication paths, components, circuit elements, circuits, functional blocks, and/or devices. As an example of indirect coupling, a signal conveyed from a first item to a second item may be modified by one or more intervening items by modifying the form, nature or format of information in a signal, while one or more elements of the information in the signal are nevertheless conveyed in a manner than can be recognized by the second item. In a further example of indirect coupling, an action in a first item can cause a reaction on the second item, as a result of actions and/or reactions in one or more intervening items.

[0128] Although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement which achieves the same or similar purpose may be substituted for the embodiments described or shown by the subject disclosure. The subject disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, can be used in the subject disclosure. For instance, one or more features from one or more embodiments can be combined with one or more features of one or more other embodiments. In one or more embodiments, features that are positively recited can also be negatively recited and excluded from the embodiment with or without replacement by another structural and/or functional feature. The steps or functions described with respect to the embodiments of the subject disclosure can be performed in any order. The steps or functions described with respect to the embodiments of the subject disclosure can be performed alone or in combination with other steps or functions of the subject disclosure, as well as from other embodiments or from other steps that have not been described in the subject disclosure. Further, more than or less than all of the features described with respect to an embodiment can also be utilized.

Claims

1. A device, comprising: a processing system including a processor; and a memory that stores executable instructions that, when executed by the processing system, facilitate performance of operations, the operations comprising: determining, in response to establishment of a new session in a wireless network, a common version of a policy rule base that resides on both a control plane

infrastructure and a user plane infrastructure of the wireless network, wherein the common version of the policy rule base is accessible by at least one user plane element to be used in the new session and at least one control plane element to be used in the new session to provide concurrent support of different policy releases for different sessions; sending to the at least one control plane element of the control plane infrastructure to be used in the new session, using vendor-specific information elements within a 3GPP Sx interface, a first message identifying the common version; and sending to the at least one user plane element of the user plane infrastructure to be used in the new session, using the vendor-specific information elements within the 3GPP Sx interface, a second message identifying the common version.

2. The device of claim 1, wherein the operations further comprise instructing each of the at least one control plane element and the at least one user plane element to utilize the common version.

3. The device of claim 1, wherein the operations further comprise: obtaining information identifying each version of a policy rule base to which a policy charging and rules function infrastructure of the wireless network has access; selecting a second common version of a policy rule base to which each of the control plane infrastructure, the user plane infrastructure, and the policy charging and rules function infrastructure have access; and communicating the identification of the second common version to the policy charging and rules function architecture.

4. The device of claim 3, wherein the communicating further comprises instructing each of the at least one control plane element, the at least one user plane element, and the policy charging and rules function architecture to utilize the second common version.

5. The device of claim 3, wherein there exists more than two common versions of the policy rule base to which each of the at least one control plane element, the at least one user plane element, and the policy charging and rules function architecture have access.

6. The device of claim 3, wherein the selecting further comprises selecting a single common version of the policy rule base to which each of the control plane infrastructure, the user plane infrastructure, and the policy charging and rules function infrastructure have access.

7. The device of claim 6, wherein the selecting is based upon an age characteristic of the single common version.

8. The device of claim 3, wherein: each version of the policy rule base to which the control plane infrastructure has access is located on the control plane infrastructure; each version of the policy rule base to which the user plane infrastructure has access is located on the user plane infrastructure; and each version of the policy rule base to which the policy charging and rules function infrastructure has access is located on the policy charging and rules function infrastructure.

9. The device of claim 3, wherein the determining comprises accessing a database.

10. The device of claim 3, wherein the determining comprises receiving information from the control plane infrastructure, the user plane infrastructure, and the policy charging and rules function infrastructure.

11. The device of claim 3, wherein each version of the policy rule base comprises an electronic document that is readable by each of the control plane infrastructure, the user plane infrastructure, and the policy charging and rules function infrastructure.

12. The device of claim 3, wherein each version of the policy rule base comprises a respective collection of line items and each line items comprises a billing parameter, an operating parameter, or any combination thereof.

13. The device of claim 12, wherein: each billing parameter comprises an indication of a pre-paid account, an indication of a post-paid account, an indication of an enterprise account, an indication of a particular service that is billable, an indication of a particular service that is not billable, or any combination thereof; and each operating parameter comprises a minimum data throughput, a maximum data throughput, a minimum data speed, a maximum data speed, a minimum bandwidth, a maximum bandwidth, a minimum amount of data, a maximum amount of data, an available

bitrate, a guaranteed bitrate, a maximum bitrate, a QoS class identifier (QCI), an allocation and retention priority (ARP), a diffserv code point (DSCP), a next-hop route selection, a virtual local area network (VLAN) tag, an optimization of video traffic, a scanning for viruses, a scanning for phishing, or any combination thereof.

14. A non-transitory machine-readable medium comprising executable instructions that, when executed by a processing system including a processor, facilitate performance of operations, the operations comprising: sending, to a control plane infrastructure of a wireless network, a particular version of a set of policies, wherein the control plane infrastructure is currently using a first set of policies that differs from the particular version of the set of policies, and wherein the particular version of the set of policies is being pre-positioned for use by the control plane infrastructure at a future time; sending, to a user plane infrastructure of the wireless network, the particular version of the set of policies, wherein the user plane infrastructure is currently using a second set of policies that differs from the particular version of the set of policies, and wherein the particular version of the set of policies is being pre-positioned for use by the user plane infrastructure at the future time; and subsequent to the sending of the particular version of the set of policies to each of the control plane infrastructure and the user plane infrastructure, and in response to a new session being established, instructing each of at least one control plane element of the control plane infrastructure and at least one user plane element of the user plane infrastructure to begin using the particular version of the set of policies that had been sent to provide concurrent support of different policy releases for different control plane elements and for different user plane elements for use in different sessions, wherein the instructing each of the at least one control plane element of the control plane infrastructure and the at least one user plane element of the user plane infrastructure to begin using the particular version of the set of policies comprises instructing, using vendor-specific information elements within a 3GPP Sx interface, each of the at least one of the control plane element of the control plane infrastructure to be used in the new session and the at least one of the user plane element of the user plane infrastructure to be used in the new session to utilize the particular version.

15. The non-transitory machine-readable medium of claim 14, wherein the operations further comprise: sending, to a policy charging and rules function infrastructure of the wireless network, the particular version of the set of policies, wherein the policy charging and rules function infrastructure is currently using a third set of policies that differs from the particular version of the set of policies, and wherein the particular version of the set of policies is being pre-positioned for use by the policy charging and rules function infrastructure at the future time; and subsequent to the sending of the particular version of the set of policies to the policy charging and rules function infrastructure, additionally instructing the policy charging and rules function infrastructure to begin using the particular version of the set of policies that had been sent.

16. The non-transitory machine-readable medium of claim 15, wherein: the instructing further causes the control plane infrastructure to stop using the first set of policies; the instructing further causes the user plane infrastructure to stop using the second set of policies; and the additionally instructing further causes the policy charging and rules function infrastructure to stop using the third set of policies.

17. The non-transitory machine-readable medium of claim 15, wherein: each of the first set of policies, the second set of policies, and the third set of policies differs from the particular version of the set of policies; and each of the first set of policies, the second set of policies, and the third set of policies is a same set of policies.

18. The non-transitory ARY machine-readable medium of claim 15, wherein: each of the first set of policies, the second set of policies, and the third set of policies differs from the particular version of the set of policies; and at least one of the first set of policies, the second set of policies, and the third set of policies differs from at least one of the first set of policies, the second set of policies, and the third set of policies.

19. A method, comprising: determining, by a processing system including a processor, in response to establishment of a new session in a wireless network, a common version of a policy rule base that resides on both a control plane infrastructure and a user plane infrastructure of the wireless network, wherein the common version of the policy rule base is accessible by at least one user plane element to be used in the new session and at least one control plane element to be used in the new session to provide concurrent support of different policy releases for different sessions; sending, by the processing system, to the at least one control plane element of the control plane infrastructure to be used in the new session, using vendor-specific information elements within a 3GPP Sx interface, a first message identifying the common version; and sending, by the processing system, to the at least one user plane element of the user plane infrastructure to be used in the new session, using the vendor-specific information elements within the 3GPP Sx interface, a second message identifying the common version.

20. The method of claim 19, further comprising receiving, by the processing system, from a policy charging and rules function infrastructure of the wireless network, a list identifying each of a plurality of versions of a policy rule base that resides on the policy charging and rules function infrastructure.