SECURE USER EQUIPMENT AND SATELLITE COMMUNICATION WITH LOCAL MEDIA ROUTING

RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application Serial No. 63/558,694 filed February 28, 2024 entitled "Secure User Equipment and Satellite Communication with Local Media Routing," the disclosure of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to wireless communications, and more specifically to user equipment (UE) to satellite to UE communication.

BACKGROUND

[0003] A wireless communications system may include one or multiple network communication devices, which may be otherwise known as network equipment (NE), supporting wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers, or the like)). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0004] The wireless communications system may support wireless device communications, and may include one or more wireless devices, such as UEs, satellites, and/or network equipment (NE), among other devices, that transmit and/or receive signaling. The wireless communications between two UEs may include a scenario in which both UEs are included in the same serving cell and the media path is switched at a satellite. In another scenario, both UEs are included in the same serving cell, and the media path is switched between two or more satellites via inter satellite links (ISL). In

another scenario, the UEs are each in different serving cells, and the media path for the wireless communications is switched between two or more satellites via the ISL.

SUMMARY

[0005] An article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on." Further, as used herein, including in the claims, a "set" may include one or more elements.

[0006] A UE for wireless communication is described. The UE may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the UE may be configured to, capable of, or operable to transmit, to a satellite, an Internet protocol (IP) configuration request; receive, from the satellite, a local IP address assigned to the UE based on the IP configuration request; transmit, to the satellite, a request to allocate at least one transport IP address and port number; receive, from the satellite, a response message indicating the at least one transport IP address and port number; and perform a connectivity test on the at least one transport IP address for data packet forwarding to an additional UE via the satellite.

[0007] A processor (e.g., a standalone processor chipset, or a component of a UE) for wireless communication is described. The processor may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the processor may be configured to, capable of, or operable to transmit, to a satellite, an IP configuration request; receive, from the satellite, a local IP address based on the IP configuration request; transmit, to the satellite, a request to allocate at least one transport IP address and port number; receive, from the satellite, a response

message indicating the at least one transport IP address and port number; and perform a connectivity test on the at least one transport IP address for data packet forwarding to a UE via the satellite.

[0008] A method performed or performable by a UE for wireless communication is described. The method may include transmitting, to a satellite, an IP configuration request; receiving, from the satellite, a local IP address assigned to the UE based on the IP configuration request; transmitting, to the satellite, a request to allocate at least one transport IP address and port number; receiving, from the satellite, a response message indicating the at least one transport IP address and port number; and performing a connectivity test on the at least one transport IP address for data packet forwarding to an additional UE via the satellite.

[0009] In some implementations of the UE, the processor, and the method described herein, the satellite comprises a session traversal utilities (STU) for network access translation (NAT) (STUN) server or a traversal using relays around NAT (TURN) server, and the satellite communicates with a proxy-call session control function (P-CSCF) as a ground IP multimedia subsystem (IMS) network. Alternatively, in some implementations of the UE, the processor, and the method described herein, the satellite comprises a STUN server or a TURN server, and the satellite includes a P-CSCF.

[0010] An NE (e.g., a satellite) for wireless communication is described. The NE may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the NE may be configured to, capable of, or operable to receive, from a first UE, a first request to allocate at least one first transport IP address and port number; transmit, to the first UE, a first response message indicating the at least one first transport IP address and port number; receive, from a second UE, a second request to allocate at least one second transport IP address and port number; transmit, to the second UE, a second response message indicating the at least one second transport IP address and port number; and perform data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0011] A processor (e.g., a standalone processor chipset, or a component of a NE) for wireless communication is described. The processor may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the processor may be configured

to, capable of, or operable to receive, from a first UE, a first request to allocate at least one first transport IP address and port number; transmit, to the first UE, a first response message indicating the at least one first transport IP address and port number; receive, from a second UE, a second request to allocate at least one second transport IP address and port number; transmit, to the second UE, a second response message indicating the at least one second transport IP address and port number; and perform data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0012] A method performed or performable by an NE (e.g., a satellite) for wireless communication is described. The method may include receiving, from a first UE, a first request to allocate at least one first transport IP address and port number; transmitting, to the first UE, a first response message indicating the at least one first transport IP address and port number; receiving, from a second UE, a second request to allocate at least one second transport IP address and port number; transmitting, to the second UE, a second response message indicating the at least one second transport IP address and port number; and performing data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0013] In some implementations of the NE, the processor, and the method described herein, the NE, the processor, and the method may be configured to, capable of, or operable to receive, from the first UE, an IP configuration request; and transmit, to the first UE, a local IP address assigned to the first UE based on the IP configuration request. In some implementations of the NE, the processor, and the method described herein, the NE comprises a satellite implemented with a STUN server or a TURN server, and the satellite is operable to communicate with a P-CSCF as a ground IMS network. Alternatively, In some implementations of the NE, the processor, and the method described herein, the NE comprises a satellite implemented with a STUN server or a TURN server, and the satellite includes a P-CSCF.

[0014] An NE (e.g., a satellite) for wireless communication is described. The NE may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the NE may be configured to, capable of, or operable to receive, from a P-CSCF, a first request to allocate at least one first transport IP address and port number for a first UE; transmit, to the P-CSCF, a first response message indicating the at least one first transport IP address and port

number for the first UE; receive, from the P-CSCF, a second request to allocate at least one second transport IP address and port number for a second UE; transmit, to the P-CSCF, a second response message indicating the at least one second transport IP address and port number for the second UE; and perform data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0015] A processor (e.g., a standalone processor chipset, or a component of a NE) for wireless communication is described. The processor may be configured to, capable of, or operable to perform one or more operations as described herein. For example, the processor may be configured to, capable of, or operable to receive, from a P-CSCF, a first request to allocate at least one first transport IP address and port number for a first UE; transmit, to the P-CSCF, a first response message indicating the at least one first transport IP address and port number for the first UE; receive, from the P-CSCF, a second request to allocate at least one second transport IP address and port number for a second UE; transmit, to the P-CSCF, a second response message indicating the at least one second transport IP address and port number for the second UE; and perform data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0016] A method performed or performable by an NE (e.g., a satellite) for wireless communication is described. The method may include receiving, from a P-CSCF, a first request to allocate at least one first transport IP address and port number for a first UE; transmitting, to the P-CSCF, a first response message indicating the at least one first transport IP address and port number for the first UE; receiving, from the P-CSCF, a second request to allocate at least one second transport IP address and port number for a second UE; transmitting, to the P-CSCF, a second response message indicating the at least one second transport IP address and port number for the second UE; and performing data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0017] In some implementations of the NE, the processor, and the method described herein, the NE, the processor, and the method may be configured to, capable of, or operable to receive, from the first UE, an IP configuration request; and transmit, to the first UE, a local IP address assigned to the first UE based on the IP configuration request. In some implementations of the NE, the

processor, and the method described herein, the NE comprises a satellite implemented with an IMS access media gateway (IMS-AGW) server, and the satellite is operable to communicate with the P-CSCF as a ground IMS network. In some implementations of the NE, the processor, and the method described herein, the NE comprises a satellite implemented with an IMS-AGW server, and the satellite includes the P-CSCF.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0019] Figure 2 illustrates an example of UE to satellite to UE communications, in accordance with aspects of the present disclosure.

[0020] Figure 3 illustrates an example of a signaling diagram for the STUN/TURN server implemented in a satellite, with P-CSCF via a ground IMS network, in accordance with aspects of the present disclosure.

[0021] Figure 4 illustrates an example of a signaling diagram for the STUN/TURN server and P-CSCF implemented in a satellite, in accordance with aspects of the present disclosure.

[0022] Figure 5 illustrates an example of a signaling diagram for IMS-AGW implemented in a satellite, with P-CSCF via a ground IMS network, in accordance with aspects of the present disclosure.

[0023] Figure 6 illustrates an example of a signaling diagram for IMS-AGW and P-CSCF implemented in a satellite, in accordance with aspects of the present disclosure.

[0024] Figure 7 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0025] Figure 8 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0026] Figure 9 illustrates an example of a network equipment (NE) in accordance with aspects of the present disclosure.

[0027] Figure 10 illustrates a flowchart of a method performed by a UE in accordance with aspects of the present disclosure.

[0028] Figure 11 illustrates a flowchart of a method performed by a NE in accordance with aspects of the present disclosure.

[0029] Figure 12 illustrates a flowchart of a method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0030] A wireless communications system may support wireless communications for one or more wireless devices, such as UEs, satellites, and/or NEs, among other devices, that transmit and/or receive signaling. The wireless communication scenarios may include UE to satellite to UE communication for multimedia services over IP multimedia subsystem (IMS), in which the control signaling is routed over IMS in the ground-based mobile network. For example, wireless communication between two UEs may include a scenario in which both UEs are included in the same serving cell and the media path is switched at a satellite. In another scenario, both UEs are included in the same serving cell, and the media path is switched between two or more satellites via ISL. In another scenario, the UEs are each in different serving cells, and the media path for the wireless communications is switched between two or more satellites via the ISL.

[0031] Aspects of the disclosure are directed to securing wireless communications between, for example two UEs, where the media path is routed locally within the same satellite or via other satellites, without traversing the ground-based network. In these communication scenarios, the wireless communications are secured to prevent attacks that may compromise privacy of the communications, where the signaling path is routed as would be expected via the IMS network, yet the media is locally routed within a satellite.

[0032] A satellite may include network function to support IMS multimedia services. The IMS application level gateway (IMS-ALG) and the IMS-AGW can be used as a STUN server and/or a TURN server within the IMS network. The STUN provides for communication with users behind a NAT firewall, and if a connection fails, the TURN can relay media traffic. However, this described scenario assumes that the IMS-AGW is behind the NAT and within the IMS network close to the proxy-call session control function (P-CSCF), hosting the IMS-ALG.

[0033] Aspects of the present disclosure are directed to communication scenarios where the control signaling is routed via the core network IMS, and the media is routed directly between two UEs served in the same serving cell. Solutions are described to either integrate a STUN/TURN server in a satellite and to NAT the traffic within the satellite, or to integrate an IMS-AGW and an IMS-ALG (P-CSCF). In one or more implementations, the satellite becomes a local network router within the serving cell of the satellite, and for integrated IMS-AGW, the satellite also becomes the entry point of the IMS network with the implementation of the P-CSCF. In an implementation, the STUN/TURN server is implemented in a satellite, with the P-CSCF via the ground-based IMS network. In another implementation, the STUN/TURN server, as well as the P-CSCF, are implemented in a satellite. In another implementation, the IMS-AGW is implemented in a satellite, with the P-CSCF via the ground-based IMS network. In another implementation, the IMS-AGW, as well as the P-CSCF, are implemented in a satellite.

[0034] The one or more implementations support established techniques for media security, and may include a key management server (KMS). The one or more implementations also support one satellite of ISL, or if multiple satellites all implement the STUN/TURN server or IMS-ALG, then the media can be routed between the satellites accordingly. The satellites may then form an IP network. The two UEs can be located for service in the same serving cell, or in different serving cells, and the two UEs may be connected to the same satellite, or to two different satellites. Other implementation options may include no P-CSCF installed in the satellite, which reduces complexity in the satellite, given that the P-CSCF would also be the entry point to the IMS network and maintains the state of each connection and the respective IMS registrations.

[0035] Aspects of the present disclosure are described in the context of a wireless communications system. Reference is made herein to communicating data or information, such as signaling communication resources and/or communications that are transmitted or received between devices. It is to be appreciated that other terms may be used interchangeably with communicating, such as signaling, transmitting, receiving, outputting, forwarding, retrieving, obtaining, and so forth.

[0036] **Figure 1** illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless

communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0037] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, network infrastructure (or infrastructure), a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0038] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

[0039] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be

referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

[0040] A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0041] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N6, or other network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other indirectly (e.g., via the CN 106). In some implementations, one or more NE 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0042] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a packet data network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NE 102 associated with the CN 106.

[0043] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N6, or other network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0044] In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0045] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0046] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0047] Additionally, or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively.#Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0048] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g.,

control information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0049] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0050] According to implementations, one or more of the NEs 102 and the UEs 104 are operable to implement various aspects of the techniques described with reference to the present disclosure. For example, a NE 102 may receive, from a first UE 104, a request to allocate a transport IP address and port number, and the NE transmits, to the first UE 104, a response message indicating the transport IP address and port number. Additionally, the NE 102 may receive, from a second UE 104, a similar request to allocate a transport IP address and port number, and the NE transmits, to the second UE 104, a response message indicating the transport IP address and port number. The NE 102 may then perform data packet forwarding between the first UE and the second UE according to the transport IP addresses and ports.

[0051] In other implementations, a NE 102 may receive, from a P-CSCF, a request to allocate a transport IP address and port number for a first UE 104, and the NE transmits, to the P-CSCF, a response message indicating the transport IP address and port number for the first UE. Additionally, the NE 102 may receive, from the P-CSCF, a similar request to allocate a transport IP address and port number for a second UE 104, and the NE transmits, to the P-CSCF, a response message indicating the transport IP address and port number for the second UE. The NE 102 may then perform data packet forwarding between the first UE and the second UE according to the transport IP addresses and ports.

[0052] In other implementations, a UE 104 may transmit, to a satellite (e.g., a NE 102, or a satellite equipped with NE), an IP configuration request, and the UE receives, from the satellite, a

local IP address assigned to the UE based on the IP configuration request. The UE 104 may transmit, to the satellite, a request to allocate a transport IP address and port number, and the UE receives, from the satellite, a response message indicating the transport IP address and port number. The UE 104 may then perform a connectivity test on the transport IP address for data packet forwarding to an additional UE 104 via the satellite.

[0053] **Figure 2** illustrates an example of UE to satellite to UE communications 200, in accordance with aspects of the present disclosure. The UE-satellite-UE communication refers to the communication between UEs 104 (e.g., UE x and UE y) under the coverage of one or more serving satellites without the user plane traffic going through the ground network 202, using local switching capabilities 204 in a satellite 206. However, in implementations where the one or more satellites are connected via ISL, which may ensure that ground network connectivity is always available. Although only the two UEs 104 are represented to be in communication, a communication session may involve more than two UEs. Note also that a satellite (or multiple satellites) may serve more than one serving cell, in which case the UEs 104 may be in different cells.

[0054] Aspects of the present disclosure include an implementation for the STUN/TURN server implemented in a satellite, with P-CSCF via a ground IMS network. In implementations, a STUN/TURN server is implemented in the satellite, and a UE requests allocation of candidate transport addresses for each media flow from the satellite. The satellite may be implemented with NAT and a local dynamic host configuration protocol (DHCP) server for assigning all UEs served by the satellite a local IP address. The UE can use a security mechanism for exchanging the respective security material for subsequent media protection in the session description protocol (SDP) offer. The call flow may not change for the mechanisms, however for key management system (KMS) support (also referred to as a key management server (KMS)), additional messages may be sent (e.g., communicated, transmitted) to request the token on both sides.

[0055] **Figure 3** illustrates an example of a signaling diagram 300 for the STUN/TURN server implemented in a satellite, with P-CSCF via a ground IMS network, in accordance with aspects of the present disclosure. This example signaling diagram 300 includes a UE-A 104, another UE-B 104, a satellite 302, an IMS 304, and a KMS 306.

[0056] In one or more implementations, the UE-A 104 (at step 1) begins candidate transport address collection by performing a request for a transport address for each media flow from the STUN server. The STUN server (at step 2) reserves one of its transport addresses for each media flow and sends the reserved transport address information back to the UE. The STUN server also reflects the source transport address of the original request for a transport address. If the UE fails to identify STUN servers, it can conclude that ICE and outbound procedures are not supported by the network, and can default to operation using the IMS-ALG procedures.

[0057] The UE-A (at steps 3, 4) repeats the procedures for requesting a transport address for each real-time transport protocol (RTP) control protocol (RTCP) flow. These steps may be executed in parallel with the described steps 1, 2, or in series. The UE-A (at step 5) may request a MIKEY-TICKET from the KMS if this media security mechanism is used. With its three candidates (locally assigned, server reflected, and relay) the UE-A (at step 6) forms an offer and forwards to its assigned P-CSCF. The UE-A includes the SP cand-type, SP rel-addr, and SP rel-port in the candidate attribute. The UE-A includes the respective security credentials in the SDP offer. To ensure subsequent responses to the offer are allowed through the NAT, the P-CSCF stores the transport address information received in the transport header of the offer.

[0058] The P-CSCF (at step 7) forwards the offer to UE-B using one of the previously established flows. If KMS is used, the IMS UE-B (at step 8) checks whether it is authorized to resolve the ticket, and if that is the case, the IMS UE-B interacts with the KMS to resolve the ticket and receive keys. The UE-B (at steps 9-12) performs the candidate gathering procedures as outlined in the described steps 1-4 above. With its three candidates (locally assigned, server reflected, and relay) the UE-B (at step 13) forms an answer and forwards to its assigned P-CSCF. The UE-B includes the respective security response parameters in the SDP answer.

[0059] The IMS (at step 14) forwards the SDP answer to the UE-A. Both UE-A and UE-B (at step 15) perform connectivity tests on each received transport address to determine which of the received transport addresses are actually reachable. If both UEs are part of the same local network served by the same satellite, the UEs could connect directly without NAT. The UE-A media (at step 16) is now routed directly to UE B at the same satellite without traversing to the core network at the ground.

[0060] Aspects of the present disclosure include an implementation for the STUN/TURN server and a P-CSCF implemented in a satellite, and the UE requests allocation of candidate transport addresses for each media flow from the satellite. The satellite may be implemented with NAT and a local DHCP server for assigning all UEs served by the satellite a local IP address. The UE can use a security mechanism for exchanging the respective security material for subsequent media protection in a SDP offer. The call flow may not change for the mechanisms, however for the KMS support, additional messages may be sent to request the token on both sides. The IMS signaling is routed to the P-CSCF at least for UE-A, which is assigned at the time of registration to the IMS.

[0061] **Figure 4** illustrates an example of a signaling diagram 400 for the STUN/TURN server and P-CSCF implemented in a satellite, in accordance with aspects of the present disclosure. This example signaling diagram 400 includes a UE-A 104, another UE-B 104, a satellite 402, an IMS 404, and a KMS 406.

[0062] In one or more implementations, the UE-A 104 (at step 1) begins candidate transport address collection by performing a request for a transport address for each media flow from the STUN server. The STUN server (at step 2) reserves one of its transport addresses for each media flow and sends the reserved transport address information back to the UE. The STUN server also reflects the source transport address of the original request for a transport address. If the UE fails to identify STUN servers, it can conclude that ICE and outbound procedures are not supported by the network, and can default to operation using the IMS-ALG procedures.

[0063] The UE-A (at steps 3, 4) repeats the procedures for requesting a transport address for each RTCP flow. These steps may be executed in parallel with the described steps 1, 2, or in series. The UE-A (at step 5) may request a MIKEY-TICKET from the KMS if this media security mechanism is used. With its three candidates (locally assigned, server reflected, and relay) the UE-A (at step 6) forms an offer and forwards to its assigned P-CSCF. The UE-A includes the SP cand-type, SP rel-addr, and SP rel-port in the candidate attribute. The UE-A includes the respective security credentials in the SDP offer. To ensure subsequent responses to the offer are allowed through the NAT, the P-CSCF stores the transport address information received in the transport header of the offer. The P-CSCF forwards the offer to the IMS.

[0064] The IMS (at step 7) forwards the offer to UE-B using one of the previously established flows. If the UE-B is also registered via the P-CSCF in the satellite, then the message traverses the P-CSCF in the satellite as well, otherwise, the registered P-CSCF at the ground IMS network is used. If KMS is used, the IMS UE-B (at step 8) checks whether it is authorized to resolve the ticket, and if that is the case, the IMS UE-B interacts with the KMS to resolve the ticket and receive keys.

[0065] The UE-B (at steps 9-12) performs the candidate gathering procedures as outlined in the described steps 1-4 above. With its three candidates (locally assigned, server reflected, and relay), the UE-B (at step 13) forms an answer and forwards to its assigned P-CSCF. The UE-B includes the respective security response parameters in the SDP answer. The IMS (at step 14) forwards the SDP answer to the UE-A. Both the UE-A and UE-B (at step 15) perform connectivity tests on each received transport address to determine which of the received transport addresses are actually reachable. If both UEs are part of the same local network served by the same satellite, the UEs could connect directly without NAT. The UE-A media (at step 16) is now routed directly to UE-B at the same satellite without traversing to the core network at the ground.

[0066] Aspects of the present disclosure include an implementation for IMS-AGW implemented in a satellite, with P-CSCF via a ground IMS network. In implementations, the satellite is hosting IMS-AGW, while the IMS-ALG is still located in the P-CSCF in the ground IMS network. It is assumed that the P-CSCF can communicate with the IMS-ALG in the satellite for transport address configuration of the SDP. The satellite be implemented with NAT and a local DHCP server for assigning all UEs served by the satellite a local IP address. The UE can use a security mechanism for exchanging the respective security material for subsequent media protection in a SDP offer. The call flow may not change for the mechanisms, however for the KMS support, additional messages may need to be sent to request the token on both sides. The IMS signaling is routed to the P-CSCF at least for UE-A (e.g., responsible for steps 3,4 and 8,9 as shown and described with reference to FIG. 5), which is assigned at the time of registration to the IMS.

[0067] **Figure 5** illustrates an example of a signaling diagram 500 for IMS-AGW implemented in a satellite, with P-CSCF via a ground IMS network, in accordance with aspects of the present disclosure. This example signaling diagram 500 includes a UE-A 104, another UE-B 104, a satellite 502, an IMS 504, and a KMS 506.

[0068] In one or more implementations, the UE 104 (at step 1) may request a MIKEY-TICKET from the KMS if this media security mechanism is used. The P-CSCF of UE-A (at step 2) receives a session initiation protocol (SIP) message with an SDP offer from UE-A and decides to invoke the IMS-ALG function for this session. The session can either be an originating or a terminating session. The SDP offer contains the transport address(es) of the UE-A, where the media flow(s) should be routed. The transport address refers to both the IP address and ports. The UE-A includes the respective security credentials in the SDP offer.

[0069] The P-CSCF of UE-A (at step 3) requests a transport address for each media flow from the IMS access gateway in the satellite. Each request contains sufficient information to determine the side of the IMS access gateway that the transport request is being requested for (e.g., local or remote side with respect to the UE-A). The IMS access gateway in the satellite (at step 4) reserves one of its transport addresses for the given side of the media flow and this transport address is sent back to the P-CSCF. The IMS access gateway in the satellite shall keep the reserved temporary transport address (binding) until the session is released. The P-CSCF (at step 5) changes the original transport address(es) of the SDP offer to the transport address(es) received from the IMS access gateway. The P-CSCF forwards the SIP message with the modified SDP offer according to the normal routing procedures. If KMS is used, the IMS UE-B (at step 6) checks whether it is authorized to resolve the ticket, and if that is the case, the IMS UE-B interacts with the KMS to resolve the ticket and receive keys.

[0070] The UE-B (at step 7) sends back a SIP message with an SDP answer, which is forwarded to the P-CSCF according to the normal SIP message routing procedures. The UE-B includes the respective security response parameters in the SDP answer. The UE-B P-CSCF may be a different one than the P-CSCF of UE-A in step 2. The routing procedure will route the SIP message to the P-CSCF of the UE-A. The P-CSCF of UE-A (at step 8) requests a transport address for each media flow in the routing domain of its own IMS network from the IMS access gateway in the satellite. The request contains sufficient information to correlate to the transport address request performed in step 3. Note that if some of the offered media flows are rejected in the answer, then the P-CSCF shall indicate this to the IMS access gateway in the satellite. The IMS access gateway in the satellite can release the resources (e.g., the transport address) reserved for that media flow. The P-CSCF may indicate directly to release the resources.

[0071] The IMS access gateway in the satellite (at step 9) reserves one of its transport addresses for the given side of the media flow and this transport address is sent back to the P-CSCF. The P-CSCF (at step 10) changes the original transport address(es) of the SDP answer to the transport address(es) received from the IMS access gateway. The P-CSCF forwards the SIP message with the modified SDP answer according to the normal SIP message routing procedures to the UE-A. The normal session completion with IMS is performed (at step 11), and the IMS-ALG (at step 12) performs the packet forwarding according to the transport address(es), where the media is secured according to the type of security mechanism used.

[0072] Aspects of the present disclosure include an implementation for IMS-AGW and P-CSCF implemented in a satellite. The satellite is hosting IMS-AGW and the IMS-ALG with the P-CSCF. The satellite may be implemented with NAT and a local DHCP server for assigning all UEs served by the satellite a local IP address. The UE can use a security mechanism for exchanging the respective security material for subsequent media protection in a SDP offer. The call flow may not change for the mechanisms, however for the KMS support, additional messages may need to be sent to request the token on both sides. The IMS signaling is routed to the P-CSCF in the satellite at least for UE-A (e.g., responsible for the steps 2-5 and 9-12 as shown and described with reference to FIG. 6), which is assigned at the time of registration to the IMS.

[0073] **Figure 6** illustrates an example of a signaling diagram 600 for IMS-AGW and P-CSCF implemented in a satellite, in accordance with aspects of the present disclosure. This example signaling diagram 600 includes a UE-A 104, another UE-B 104, a satellite 602, an IMS 604, and a KMS 606.

[0074] In one or more implementations, the UE 104 (at step 1) may request a MIKEY-TICKET from the KMS if this media security mechanism is used. The P-CSCF of UE-A in the satellite (at step 2) receives a SIP message with an SDP offer from the UE-A and determines to invoke the IMS-ALG function for this session. The session can be either an originating or a terminating session. The SDP offer contains the transport address(es) of UE-A, where the media flow(s) should be routed. The transport address refers to both the IP address and ports. The UE-A includes the respective security credentials in the SDP offer.

[0075] The P-CSCF of UE-A in the satellite (at step 3) requests a transport address for each media flow from the IMS access gateway in the satellite. Each request contains sufficient information to determine the side of the IMS access gateway that the transport request is being requested for (e.g., local or remote side with respect to the UE-A). The IMS access gateway in the satellite (at step 4) reserves one of its transport addresses for the given side of the media flow and this transport address is sent back to the P-CSCF in the satellite. The IMS access gateway in the satellite shall keep the reserved temporary transport address (binding) until the session is released.

[0076] The P-CSCF in the satellite (at step 5) changes the original transport address(es) of the SDP offer to the transport address(es) received from the IMS access gateway. The P-CSCF in the satellite forwards the SIP message with the modified SDP offer according to the normal routing procedures. The IMS (at step 6) forwards the offer to UE-B using one of the previously established flows. If the UE-B is also registered via the P-CSCF in the satellite, then the message traverses the P-CSCF in the satellite as well, otherwise, the registered P-CSCF at the ground IMS network is used.

[0077] If KMS is used, the IMS UE-B (at step 7) checks whether it is authorized to resolve the ticket, and if that is the case, IMS UE-B interacts with the KMS to resolve the ticket and receive keys. The UE-B (at step 8) sends back a SIP message with an SDP answer, which is forwarded to the P-CSCF according to the normal SIP message routing procedures. The UE-B includes the respective security response parameters in the SDP answer. The UE-B P-CSCF may be a different one than the P-CSCF of the UE-A in step 2. The routing procedure (at step 9) will route the SIP message to the P-CSCF of the UE-A in the satellite.

[0078] The P-CSCF of the UE-A in the satellite (at step 10) requests a transport address for each media flow in the routing domain of its own IMS network from the IMS access gateway in the satellite. The request contains sufficient information to correlate to the transport address request performed in step 3. Note that if some of the offered media flows are rejected in the answer, then the P-CSCF in the satellite shall indicate this to the IMS access gateway in the satellite. The IMS access gateway in the satellite can release the resources (e.g., the transport address) reserved for that media flow. The P-CSCF in the satellite may indicate directly to release the resources.

[0079] The IMS access gateway in the satellite (at step 11) reserves one of its transport addresses for the given side of the media flow and this transport address is sent back to the P-CSCF in the satellite. The P-CSCF in the satellite (at step 12) changes the original transport address(es) of the SDP answer to the transport address(es) received from the IMS access gateway. The P-CSCF in the satellite forwards the SIP message with the modified SDP answer according to the normal SIP message routing procedures to the UE-A. The normal session completion with IMS is performed (at step 13), and the IMS-ALG (at step 14) performs the packet forwarding according to the transport address(es), where the media is secured according to the type of security mechanism used.

[0080] **Figure 7** illustrates an example of a UE 700 in accordance with aspects of the present disclosure. The UE 700 may include a processor 702, a memory 704, a controller 706, and a transceiver 708. The processor 702, the memory 704, the controller 706, or the transceiver 708, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0081] The processor 702, the memory 704, the controller 706, or the transceiver 708, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0082] The processor 702 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 702 may be configured to operate the memory 704. In some other implementations, the memory 704 may be integrated into the processor 702. The processor 702 may be configured to execute computer-readable instructions stored in the memory 704 to cause the UE 700 to perform various functions of the present disclosure.

[0083] The memory 704 may include volatile or non-volatile memory. The memory 704 may store computer-readable, computer-executable code including instructions when executed by the

processor 702 cause the UE 700 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the memory 704 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0084] In some implementations, the processor 702 and the memory 704 coupled with the processor 702 may be configured to cause the UE 700 to perform one or more of the functions described herein (e.g., executing, by the processor 702, instructions stored in the memory 704). For example, the processor 702 may support wireless communication at the UE 700 in accordance with examples as disclosed herein. The UE 700 may be configured to or operable to support a means for transmitting, to a satellite, an IP configuration request; receiving, from the satellite, a local IP address assigned to the UE based on the IP configuration request; transmitting, to the satellite, a request to allocate at least one transport IP address and port number; receiving, from the satellite, a response message indicating the at least one transport IP address and port number; and performing a connectivity test on the at least one transport IP address for data packet forwarding to an additional UE via the satellite.

[0085] Additionally, the UE 700 may be configured to support any one or combination of the satellite comprises a STUN server or a TURN server, and the satellite communicates with a P-CSCF as a ground IMS network. The satellite comprises a STUN server or a TURN server, and the satellite includes a P-CSCF.

[0086] Additionally, or alternatively, the UE 700 may support at least one memory (e.g., the memory 704) and at least one processor (e.g., the processor 702) coupled with the at least one memory and configured to cause the UE to transmit, to a satellite, an IP configuration request; receive, from the satellite, a local IP address assigned to the UE based on the IP configuration request; transmit, to the satellite, a request to allocate at least one transport IP address and port number; receive, from the satellite, a response message indicating the at least one transport IP address and port number; and perform a connectivity test on the at least one transport IP address for data packet forwarding to an additional UE via the satellite.

[0087] Additionally, the UE 700 may be configured to support any one or combination of the satellite comprises a STUN server or a TURN server, and the satellite communicates with a P-CSCF as a ground IMS network. The satellite comprises a STUN server or a TURN server, and the satellite includes a P-CSCF.

[0088] The controller 706 may manage input and output signals for the UE 700. The controller 706 may also manage peripherals not integrated into the UE 700. In some implementations, the controller 706 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 706 may be implemented as part of the processor 702.

[0089] In some implementations, the UE 700 may include at least one transceiver 708. In some other implementations, the UE 700 may have more than one transceiver 708. The transceiver 708 may represent a wireless transceiver. The transceiver 708 may include one or more receiver chains 710, one or more transmitter chains 712, or a combination thereof.

[0090] A receiver chain 710 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 710 may include one or more antennas to receive a signal over the air or wireless medium. The receiver chain 710 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 710 may include at least one demodulator configured to demodulate the received signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 710 may include at least one decoder for decoding the demodulated signal to receive the transmitted data.

[0091] A transmitter chain 712 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 712 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 712 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate

power level suitable for transmission over the wireless medium. The transmitter chain 712 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0092] **Figure 8** illustrates an example of a processor 800 in accordance with aspects of the present disclosure. The processor 800 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 800 may include a controller 802 configured to perform various operations in accordance with examples as described herein. The processor 800 may optionally include at least one memory 804, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 800 may optionally include one or more arithmetic-logic units (ALUs) 806. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0093] The processor 800 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 800)) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0094] The controller 802 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 800 to cause the processor 800 to support various operations in accordance with examples as described herein. For example, the controller 802 may operate as a control unit of the processor 800, generating control signals that manage the operation of various components of the processor 800. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0095] The controller 802 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 804 and determine subsequent instruction(s) to be executed to cause the processor 800 to support various operations in accordance with examples as described herein. The controller 802 may be configured to track memory addresses of instructions associated with the memory 804. The controller 802 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 802 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 800 to cause the processor 800 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 802 may be configured to manage flow of data within the processor 800. The controller 802 may be configured to control transfer of data between registers, ALUs 806, and other functional units of the processor 800.

[0096] The memory 804 may include one or more caches (e.g., memory local to or included in the processor 800) or other memory, such as RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 804 may reside within or on a processor chipset (e.g., local to the processor 800). In some other implementations, the memory 804 may reside external to the processor chipset (e.g., remote to the processor 800).

[0097] The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 800, cause the processor 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 802 and/or the processor 800 may be configured to execute computer-readable instructions stored in the memory 804 to cause the processor 800 to perform various functions. For example, the processor 800 and/or the controller 802 may be coupled with or to the memory 804, the processor 800, the controller 802, and the memory 804 may be configured to perform various functions described herein. In some examples, the processor 800 may include multiple processors and the memory 804 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0098] The one or more ALUs 806 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more

ALUs 806 may reside within or on a processor chipset (e.g., the processor 800). In some other implementations, the one or more ALUs 806 may reside external to the processor chipset (e.g., the processor 800). One or more ALUs 806 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 806 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 806 may be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 806 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 806 to handle conditional operations, comparisons, and bitwise operations.

[0099] The processor 800 may support wireless communication in accordance with examples as disclosed herein. The processor 800 may be configured to or operable to support at least one controller (e.g., the controller 802) coupled with at least one memory (e.g., the memory 804) and configured to cause the processor to transmit, to a satellite, an IP configuration request; receive, from the satellite, a local IP address based on the IP configuration request; transmit, to the satellite, a request to allocate at least one transport IP address and port number; receive, from the satellite, a response message indicating the at least one transport IP address and port number; and perform a connectivity test on the at least one transport IP address for data packet forwarding to a UE via the satellite.

[0100] Additionally, the processor 800 may be configured to or operable to support any one or combination of the satellite comprises a STUN server or a TURN server, and the satellite communicates with a P-CSCF as a ground IMS network. The satellite comprises a STUN server or a TURN server, and the satellite includes a P-CSCF.

[0101] **Figure 9** illustrates an example of a NE 900 in accordance with aspects of the present disclosure. The NE 900 may include a processor 902, a memory 904, a controller 906, and a transceiver 908. The processor 902, the memory 904, the controller 906, or the transceiver 908, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0102] The processor 902, the memory 904, the controller 906, or the transceiver 908, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0103] The processor 902 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 902 may be configured to operate the memory 904. In some other implementations, the memory 904 may be integrated into the processor 902. The processor 902 may be configured to execute computer-readable instructions stored in the memory 904 to cause the NE 900 to perform various functions of the present disclosure.

[0104] The memory 904 may include volatile or non-volatile memory. The memory 904 may store computer-readable, computer-executable code including instructions when executed by the processor 902 cause the NE 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the memory 904 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0105] In some implementations, the processor 902 and the memory 904 coupled with the processor 902 may be configured to cause the NE 900 to perform one or more of the functions described herein (e.g., executing, by the processor 902, instructions stored in the memory 904). For example, the processor 902 may support wireless communication at the NE 900 in accordance with examples as disclosed herein. The NE 900 may be configured to or operable to support a means for receiving, from a first UE, a first request to allocate at least one first transport IP address and port number; transmitting, to the first UE, a first response message indicating the at least one first transport IP address and port number; receiving, from a second UE, a second request to allocate at least one second transport IP address and port number; transmitting, to the second UE, a second response message indicating the at least one second transport IP address and port number; and

performing data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0106] Additionally, the NE 900 may be configured to or operable to support any one or combination of the method further including receiving, from the first UE, an IP configuration request; and transmitting, to the first UE, a local IP address assigned to the first UE based on the IP configuration request. The NE comprises a satellite implemented with a STUN server or a TURN server, and the satellite is configured to communicate with a P-CSCF as a ground IMS network. The NE comprises a satellite implemented with a STUN server or a TURN server, and the satellite includes a P-CSCF.

[0107] Additionally, or alternatively, the NE 900 may support at least one memory (e.g., the memory 904) and at least one processor (e.g., the processor 902) coupled with the at least one memory and configured to cause the NE to receive, from a first UE, a first request to allocate at least one first transport IP address and port number; transmit, to the first UE, a first response message indicating the at least one first transport IP address and port number; receive, from a second UE, a second request to allocate at least one second transport IP address and port number; transmit, to the second UE, a second response message indicating the at least one second transport IP address and port number; and perform data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0108] Additionally, the NE 900 may be configured to support any one or combination of the processor is configured to cause the NE to receive, from the first UE, an IP configuration request; and transmit, to the first UE, a local IP address assigned to the first UE based on the IP configuration request. The NE comprises a satellite implemented with a STUN server or a TURN server, and the satellite is configured to communicate with a P-CSCF as a ground IMS network. The NE comprises a satellite implemented with a STUN server or a TURN server, and the satellite includes a P-CSCF.

[0109] In some implementations, the processor 902 and the memory 904 coupled with the processor 902 may be configured to cause the NE 900 to perform one or more of the functions described herein (e.g., executing, by the processor 902, instructions stored in the memory 904). For

example, the processor 902 may support wireless communication at the NE 900 in accordance with examples as disclosed herein. The NE 900 may be configured to or operable to support a means for receiving, from a P-CSCF, a first request to allocate at least one first transport IP address and port number for a first UE; transmitting, to the P-CSCF, a first response message indicating the at least one first transport IP address and port number for the first UE; receiving, from the P-CSCF, a second request to allocate at least one second transport IP address and port number for a second UE; transmitting, to the P-CSCF, a second response message indicating the at least one second transport IP address and port number for the second UE; and performing data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0110] Additionally, the NE 900 may be configured to or operable to support any one or combination of the method further including receiving, from the first UE, an IP configuration request; and transmitting, to the first UE, a local IP address assigned to the first UE based on the IP configuration request. The NE comprises a satellite implemented with an IMS-AGW server, and where the satellite is configured to communicate with the P-CSCF as a ground IMS network. The NE comprises a satellite implemented with an IMS-AGW server, and the satellite includes the P-CSCF.

[0111] Additionally, or alternatively, the NE 900 may support at least one memory (e.g., the memory 904) and at least one processor (e.g., the processor 902) coupled with the at least one memory and configured to cause the NE to receive, from a P-CSCF, a first request to allocate at least one first transport IP address and port number for a first UE; transmit, to the P-CSCF, a first response message indicating the at least one first transport IP address and port number for the first UE; receive, from the P-CSCF, a second request to allocate at least one second transport IP address and port number for a second UE; transmit, to the P-CSCF, a second response message indicating the at least one second transport IP address and port number for the second UE; and perform data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address.

[0112] Additionally, the NE 900 may be configured to support any one or combination of the processor is configured to cause the NE to receive, from the first UE, an IP configuration request; and transmit, to the first UE, a local IP address assigned to the first UE based on the IP

configuration request. The NE comprises a satellite implemented with an IMS-AGW server, and the satellite is configured to communicate with the P-CSCF as a ground IMS network. The NE comprises a satellite implemented with an IMS-AGW server, and the satellite includes the P-CSCF.

[0113] The controller 906 may manage input and output signals for the NE 900. The controller 906 may also manage peripherals not integrated into the NE 900. In some implementations, the controller 906 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 906 may be implemented as part of the processor 902.

[0114] In some implementations, the NE 900 may include at least one transceiver 908. In some other implementations, the NE 900 may have more than one transceiver 908. The transceiver 908 may represent a wireless transceiver. The transceiver 908 may include one or more receiver chains 910, one or more transmitter chains 912, or a combination thereof.

[0115] A receiver chain 910 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 910 may include one or more antennas to receive a signal over the air or wireless medium. The receiver chain 910 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 910 may include at least one demodulator configured to demodulate the received signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 910 may include at least one decoder for decoding the demodulated signal to receive the transmitted data.

[0116] A transmitter chain 912 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 912 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 912 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 912 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0117] **Figure 10** illustrates a flowchart of a method 1000 in accordance with aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, the UE may execute a set of instructions to control the function elements of the UE to perform the described functions. It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0118] At 1002, the method may include transmitting, to a satellite, an IP configuration request. The operations of 1002 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1002 may be performed by a UE as described with reference to Figure 7.

[0119] At 1004, the method may include receiving, from the satellite, a local IP address assigned to the UE based on the IP configuration request. The operations of 1004 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1004 may be performed by a UE as described with reference to Figure 7.

[0120] At 1006, the method may include transmitting, to the satellite, a request to allocate at least one transport IP address and port number. The operations of 1006 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1006 may be performed by a UE as described with reference to Figure 7.

[0121] At 1008, the method may include receiving, from the satellite, a response message indicating the at least one transport IP address and port number. The operations of 1008 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1008 may be performed by a UE as described with reference to Figure 7.

[0122] At 1010, the method may include performing a connectivity test on the at least one transport IP address for data packet forwarding to an additional UE via the satellite. The operations of 1010 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1010 may be performed by a UE as described with reference to Figure 7.

[0123] **Figure 11** illustrates a flowchart of a method 1100 in accordance with aspects of the present disclosure. The operations of the method may be implemented by a NE as described herein.

In some implementations, the NE may execute a set of instructions to control the function elements of the NE to perform the described functions. It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0124] At 1102, the method may include receiving, from a first UE, a first request to allocate at least one first transport IP address and port number. The operations of 1102 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1102 may be performed by a NE as described with reference to Figure 9.

[0125] At 1104, the method may include transmitting, to the first UE, a first response message indicating the at least one first transport IP address and port number. The operations of 1104 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1104 may be performed by a NE as described with reference to Figure 9.

[0126] At 1106, the method may include receiving, from a second UE, a second request to allocate at least one second transport IP address and port number. The operations of 1106 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1106 may be performed by a NE as described with reference to Figure 9.

[0127] At 1108, the method may include transmitting, to the second UE, a second response message indicating the at least one second transport IP address and port number. The operations of 1108 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1108 may be performed by a NE as described with reference to Figure 9.

[0128] At 1110, the method may include performing data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address. The operations of 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1110 may be performed by a NE as described with reference to Figure 9.

[0129] **Figure 12** illustrates a flowchart of a method 1200 in accordance with aspects of the present disclosure. The operations of the method may be implemented by a NE as described herein. In some implementations, the NE may execute a set of instructions to control the function elements

of the NE to perform the described functions. It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0130] At 1202, the method may include receiving, from a P-CSCF, a first request to allocate at least one first transport IP address and port number for a first UE. The operations of 1202 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1202 may be performed by a NE as described with reference to Figure 9.

[0131] At 1204, the method may include transmitting, to the P-CSCF, a first response message indicating the at least one first transport IP address and port number for the first UE. The operations of 1204 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1204 may be performed by a NE as described with reference to Figure 9.

[0132] At 1206, the method may include receiving, from the P-CSCF, a second request to allocate at least one second transport IP address and port number for a second UE. The operations of 1206 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1206 may be performed by a NE as described with reference to Figure 9.

[0133] At 1208, the method may include transmitting, to the P-CSCF, a second response message indicating the at least one second transport IP address and port number for the second UE. The operations of 1208 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1208 may be performed by a NE as described with reference to Figure 9.

[0134] At 1210, the method may include performing data packet forwarding between the first UE and the second UE according to the at least one first transport IP address and the at least one second transport IP address. The operations of 1210 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1210 may be performed by a NE as described with reference to Figure 9.

[0135] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person

having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.