Description

Title of Invention: COMMUNICATION APPARATUS AND COMMUNICATION METHOD FOR SERVICE DISCOVERY FOR LOCAL AREA NETWORK

TECHNICAL FIELD

[001] The present disclosure generally relates to communication methods and apparatuses, and more particularly relates to methods and apparatuses for service discovery for local area network.

BACKGROUND

[002] Dedicated Short Range Communications (DSRC) is defined in IEEE 802.11p and is used for vehicle-to-infrastructure (V2I) communication. Wi-Fi based on other IEEE 802.11 variants including 11n and 11ad have also been considered for V2I use. In V2I, servers may be deployed close to the area of communication to provide faster services. These are commonly known as edge servers.

[003] However, there is still limited discussion on communication apparatuses and methods for service discovery for local area network, especially on communication apparatuses and methods discovering services and/or servers in local/regional area networks quickly.

[004] There is thus a need for communication apparatuses and methods that can solve the above-mentioned issues. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[005] Non-limiting and exemplary embodiments facilitate providing communication apparatuses and communication methods for service discovery for local area network.

[006] According to an aspect of the present disclosure, there is provided a communication apparatus comprising: a transceiver, which in operation, is configured to: exchange messages with a Dynamic Host Configuration Protocol (DHCP) server via a first local area network (LAN);

and communicate with a service discovery server based on an address of the service discovery server indicated by a message from the DHCP server.

[007] According to another aspect of the present disclosure, there is provided a communication method comprising: exchanging messages with a DHCP server via a first LAN; and communicating with a service discovery server based on an address of the service discovery server indicated by a message from the DHCP server.

[008] According to another aspect of the present disclosure, there is provided a communication apparatus comprising: a communication interface; and circuitry, which in operation, acquires, via the communication interface, a list of at least one application service from a service discovery server, and requests an application service based on the list.

[009] It should be noted that general or specific embodiments may be implemented as a system, a method, an integrated circuit, a computer program, a storage medium, or any selective combination thereof. Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying figures where like reference numerals refer to identical or functionally similar elements throughout the separate views and which together with the detailed description below are incorporated in and form part of the specification, serve to illustrate various embodiments and to explain various principles and advantages in accordance with present embodiments.

[0011] FIG. 1 depicts a schematic diagram of a system for service discovery for local area network according to an embodiment of the present disclosure.

[0012] FIG. 2 depicts a message sequence chart according to an embodiment of the present disclosure.

[0013] FIG. 3 depicts a server and/or client authentication procedure according to various embodiments of the present disclosure.

[0014] FIG. 4 depicts a flowchart illustrating the behaviour of a mobile terminal according to an embodiment of the present disclosure.

[0015] FIG. 5 depicts a message format for DHCPOFFER and DHCPACK with Default World Wide Web (WWW) Server Option according to various embodiments of the present disclosure.

[0016] FIG. 6 depicts a message format for DHCPDISCOVER and DHCPREQUEST with Parameter Request List Option according to various embodiments of the present disclosure.

[0017] FIG. 7 depicts an example message format for a list of addresses and/or information relating to services and/or servers according to various embodiments of the present disclosure.

[0018] FIG. 8 depicts a block diagram of a mobile terminal according to an embodiment of the present disclosure.

[0019] FIG. 9 depicts a block diagram of an access point (AP) with Dynamic Host Configuration Protocol (DHCP) server function according to an embodiment of the present disclosure.

[0020] FIG. 10 depicts a block diagram of an application server with service discovery server function according to an embodiment of the present disclosure.

[0021] FIG. 11 depicts a schematic diagram of a system for service discovery for local area network according to another embodiment of the present disclosure.

[0022] FIG. 12 depicts a message sequence chart according to another embodiment of the present disclosure.

[0023] FIG. 13 depicts a flowchart illustrating the behaviour of a mobile terminal according to another embodiment of the present disclosure.

[0024] FIG. 14 depicts a flowchart illustrating the behaviour of a router according to another embodiment of the present disclosure.

[0025] FIG. 15 depicts a flowchart illustrating the behaviour of an application host according to another embodiment of the present disclosure.

[0026] Fig. 16 depicts a block diagram of a mobile terminal according to another embodiment of the present disclosure.

[0027] FIG. 17 depicts a block diagram of a router according to another embodiment of the present disclosure.

[0028] FIG. 18 depicts a block diagram of an application host according to another embodiment of the present disclosure.

[0029] FIG. 19 depicts a schematic diagram of a system for service discovery for local area network according to yet another embodiment of the present disclosure.

[0030] Fig. 20 depicts a message sequence chart according to yet another embodiment of the present disclosure.

[0031] FIG. 21 depicts a flowchart illustrating the behaviour of a mobile terminal according to yet another embodiment of the present disclosure.

[0032] FIG. 22 depicts a flowchart illustrating the behaviour of an application host according to yet another embodiment of the present disclosure.

[0033] Fig. 23 depicts a block diagram of a mobile terminal according to yet another embodiment of the present disclosure.

[0034] FIG. 24 depicts a block diagram of an application host according to yet another embodiment of the present disclosure.

[0035] FIG. 25 depicts a schematic diagram of a system for service discovery for local area network according to still yet another embodiment of the present disclosure.

[0036] Fig. 26 depicts a message sequence chart according to still yet another embodiment of the present disclosure.

[0037] FIG. 27 depicts a flowchart illustrating the behaviour of a mobile terminal according to still yet another embodiment of the present disclosure.

[0038] FIG. 28 depicts a flowchart illustrating the behaviour of an application host according to still yet another embodiment of the present disclosure.

[0039] Fig. 29 depicts a block diagram of a mobile terminal according to still yet another embodiment of the present disclosure.

[0040] FIG. 30 depicts a block diagram of an application host according to still yet another embodiment of the present disclosure.

[0041] FIG. 31 shows a flow diagram illustrating a method for service discovery for local area network according to various embodiments of the present disclosure.

[0042] FIG. 32 shows a schematic, partially sectioned view of a communication apparatus that can be implemented for service discovery for local area network in accordance with various embodiments of the present disclosure.

[0043] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale.

DETAILED DESCRIPTION

[0044] The following detailed description is merely exemplary in nature and is not intended to limit the embodiments or the application and uses of the embodiments. There is no intention to be bound by any theory presented in the preceding Background or this detailed description. Furthermore, other desirable features and characteristics will become apparent from the

subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

[0045] Some embodiments of the present disclosure will be described, by way of example only, with reference to the drawings. Like reference numerals and characters in the drawings refer to like elements or equivalents.

[0046] In the following paragraphs, certain exemplifying embodiments are explained with reference to an access point (AP) and a station (STA) for service discovery for local area network.

[0047] In the context of IEEE 802.11 (Wi-Fi) technologies, a station, which is interchangeably referred to as a STA, is a communication apparatus that has the capability to use the 802.11 protocol. Based on the IEEE 802.11-2020 definition, a STA can be any device that contains an IEEE 802.11-conformant media access control (MAC) and physical layer (PHY) interface to the wireless medium (WM).

For example, a station may be a laptop, a desktop personal computer (PC), a personal digital assistant (PDA), either an access point or not (e.g., either an AP STA or a non-AP STA), or a Wi-Fi phone in a wireless local area network (WLAN) environment. The station may be fixed or mobile. In the WLAN environment, the terms “STA”, “non-AP STA”, “client”, “wireless client”, “user”, “user device”, and “mobile terminal” are often used interchangeably.

[0048] Likewise, an AP, which may be interchangeably referred to as a wireless access point (WAP) in the context of IEEE 802.11 (Wi-Fi) technologies, is a communication apparatus that allows STAs in a WLAN to connect to a wired network. The AP usually connects to a router (via a wired network) as a standalone device, but it can also be integrated with or employed in the router.

[0049] As mentioned above, a STA in a WLAN may work as an AP at different occasions, and vice versa. This is because communication apparatuses in the context of IEEE 802.11 (Wi-Fi) technologies may include both STA hardware components and AP hardware components. In this manner, the communication apparatuses may switch between a STA mode and an AP mode, based on actual WLAN conditions and/or requirements.

[0050] So far, there is no study or discussion about a method that enables mobile terminals to discover services or servers in a local or regional area network with minimal delay. The present disclosure provides a means for mobile terminals to discover services and servers in a local area network quickly. In a likely application in vehicle-to-infrastructure (V2I) communications, the mobile terminal may be installed in a vehicle.

[0051] In an embodiment, the following solution is proposed to address the above-mentioned issues. Referring to the schematic diagram of FIG. 1 according to the embodiment, a system 100 includes a wireless access point (AP) 104, a DHCP server 106, a service discovery server 110, an application server 108 and a mobile terminal 102. The mobile terminal 102 sets up a wireless connection (e.g., a first local area network LAN1) with the AP 104 when it comes into the communication range of the AP 104. The wireless connection may be based on IEEE802.11 protocol (e.g., IEEE802.11ad (11ad), 11ay, 11n, 11ac, 11ax, 11be, etc.). The wireless access point 104, DHCP server 106, service discovery server 110 and application server 108 may be connected to each other through a local area network (e.g., a second local area network LAN2). One or more of the wireless access point 104, DHCP server 106, service discovery server 110 and application server 108 may be collocated on a same device and there may be one or more of each of these in the system. A typical case may be to collocate the wireless AP 104 with the DHCP server 106, in which case, the wireless AP 104 acts as a router to connect the wireless LAN (LAN1) and the local area network (LAN2) which may be on different subnets. In another case, the wireless AP 104 may act as a bridge to connect the wireless LAN (LAN1) and the local area network (LAN2) which may be on the same subnet or on a subnet with overlapping range of addresses (e.g., with network configuration using Proxy Address Resolution Protocol (ARP)). The mobile terminal can, advantageously, start using the service that is being provided by a server on LAN2 via the LAN1 connection with small delay after connecting to LAN1.

[0052] In an implementation, a connection between the mobile terminal 102 and LAN1 is established, for example, through IEEE 802.11 association with the wireless AP 104. The mobile terminal 102 then obtains an IP address to be used for subsequent communication and the address of the service discovery server 110 from the DHCP server 106 instance through a DHCP message exchange sequence. The DHCP server 106 includes the address of the service discovery server 110 in a DHCP message, for example, in a DHCP option inside a DHCPOFFER and/or DHCPACK message. The DHCP option may be, without limitation, a Default World Wide Web (WWW) Server Option, Vendor Specific Information, or a Default URL. The mobile terminal

102 may solicit this by specifying the option code in a Parameter Request List Option inside the DHCPDISCOVER and/or DHCPREQUEST message and/or the DHCP server 106 may include the DHCP option without solicitation. The mobile terminal 102 then transmits a message, for example a Hypertext Transfer Protocol (HTTP) GET request, to the service discovery server 110 address and receives a response, for example a HTTP response, containing a list of addresses and/or information relating to one or more servers including the application server 108 and/or services of one or more servers including the application server 108 that may be available on the local area network (e.g., LAN2). The mobile terminal 102 may then request the service directly with the application server 108. It will be appreciated that the services of the one or more servers may interchangeably be referred to as application services.

[0053] FIG. 2 depicts a message sequence chart 200 according to an embodiment of the present disclosure. A connection is first established between mobile terminal 202 and AP 204 (e.g., LAN1) via an association process 212. For IEEE 802.11 protocols, the association process 212 may include scanning, association, and authentication procedures. Upon establishment of the connection (LAN1), the mobile terminal 202 initiates a DHCP procedure by sending a DHCPDISCOVER broadcast message 214 over LAN1. The DHCPDISCOVER message 214 is received by the DHCP server 206 via the AP 204 and the DHCP server returns a DHCPOFFER message 216 with an IP address to be used by the mobile terminal 202, and the IP address of a service discovery server 210 in a DHCP option, for example, in a Default WWW Server Option. The mobile terminal 202 sends a DHCPREQUEST 218 to the DHCP server 206 to indicate acceptance of the IP address and receives a DHCPACK 220 in response. The DHCPDISCOVER 214 and/or the DHCPREQUEST 218 may include a Parameter Request List Option to solicit the DHCP option containing the IP address of the service discovery server 210. After obtaining its IP address and the IP address of the service discovery server 210, the mobile terminal 202 may proceed, as part of a service discovery process, to send a HTTP GET request 222 to the service discovery server 210 and receive a HTTP response 224 indicating a list of addresses and/or information relating to one or more servers including the application server 208 and/or services of one or more servers including the application server 208 that may be available, for example, available on LAN2. The mobile terminal 202 may specify a predetermined path for service discovery (e.g., “/”, “/sd”, “/servicediscovery”) in the request target element of the first line of the HTTP GET request 222. In a variation, the mobile terminal 202 may specify a complete URL (e.g., https://192.168.0.1/servicediscovery) that includes the protocol scheme (e.g., https://), the service discovery server address (e.g., 192.168.0.1) and the predetermined path for service discovery

(e.g., /servicediscovery). The mobile terminal 202 may include information related to desired services or its capabilities in the HTTP request 222 which may affect the content of the HTTP response 224. The service discovery server 210 sends, in response to the request 222 from the mobile terminal 202, a list of addresses and/or information relating to one or more servers including the application server 208 and/or services of one or more servers including the application server 208 that may be available, for example, available on LAN2. The mobile terminal 202 may then proceed to request (e.g., via request message 226) and access (e.g., via service provision 228) one or more of the available application servers 208 and/or respective services.

[0054] In a variation, the DHCP option (e.g., the Default WWW Server Option) may contain more than one IP address and the address of the service discovery server 210 may be identified by its position in the option (e.g., the first or the last address).

[0055] In another variation, the DHCP option (e.g., the Default WWW Server Option) may contain IP addresses of multiple service discovery servers. The mobile terminal 202 may send a HTTP GET request 222 to one or more of the multiple service discovery servers.

[0056] In yet another variation, the DHCP option (e.g., the Default WWW Server Option) may, in addition, contain the IP address of an application host. When the IP address of an application host is received by the mobile terminal 202, the HTTP request/response 222/224 exchange with the service discovery server 210 may be skipped and the mobile terminal 202 may proceed to request the service directly with the application host if the address of the application server 208 is expected or known by the mobile terminal 202.

[0057] In still yet another variation, the mobile terminal 202 may specify desired services or advertise its capabilities in a DHCP option (e.g., Vendor Specific Information) inside the DHCPDISCOVER 214 and/or DHCPREQUEST 218 which may affect the content of the Default WWW Server Option returned by the DHCP server 206. For example, a server address may be provided by the DHCP server 206 only if the mobile terminal 202 advertises support of a particular capability.

[0058] In still even yet another variation, the mobile terminal 202 may also advertise a service discovery server address to the DHCP Server 206 inside the DHCPDISCOVER 214 and/or DHCPREQUEST 218 messages in order to make known its own services.

[0059] The application server 208 may perform a service registration process (not shown in FIG. 2) when it starts a service to register the service with the service discovery server. As an example, the application server 208 may transmit a message (e.g., HTTP POST request, HTTP PUT request, message over MQTT, etc.) that contains the address of the application server 208 (e.g., IP address, Fully Qualified Domain Name (FQDN) such as hostname.example.com and hostname.local, and/or hostname specified by an operating system (OS) such as Linux, Windows, etc.) and/or information of the services that the application server 208 is providing, to the service discovery server 210. Additionally or alternatively, a service registration process may be performed by the service discovery server 210, for example, by scanning for servers and/or services on the local area network (e.g., LAN2). The service discovery server may perform the scanning, for example, using multicast domain name system (mDNS) and/or domain name system based service discovery (DNS-SD). In general, the service discovery process performed by the mobile terminal 202 should be performed quickly after the mobile terminal 202 establishes a connection to the local area network (e.g., LAN1), while the service registration process by the service discovery server 210 may not need to be performed so quickly. For example, a service registration process by the service discovery server 210 may be performed periodically to register new services. After a service registration process by a service discovery server (e.g., service discovery server 210) and/or by an application server (e.g., application server 208) has been conducted, the service discovery server may include in the response (e.g., HTTP response 224) to a mobile terminal (e.g., mobile terminal 202) performing a service discovery process, the address of the application servers (e.g., application server 208) and/or the information of the services that were registered during the service registration process.

[0060] The service request procedure between the mobile terminal 202 and the application server 208 may include server and/or client authentication. Referring to a server and/or client authentication procedure 300 of FIG. 3 based on a server-client secure sockets layer (SSL) authentication as an example, the mobile terminal 202 sends a client hello message 502 to the application server 208, and receives a response message 304 including a server certificate and a request for client certificate from the application server 208. The mobile terminal 202 then sends its client certificate 306 to the application server 208. This is followed by establishment of encrypted communication 308 between the mobile terminal 202 and the application server 208. The mobile terminal 202 may then proceed to (e.g., via request message 226) and access (e.g., via service provision 228) the application server/service using encrypted communication.

[0061] FIG. 4 depicts a flowchart 400 illustrating the behaviour of a communication apparatus, e.g., mobile terminal 202, according to an embodiment. The process starts at step 402. In step 404, the mobile terminal associates with an AP and establishes a connection (e.g., LAN1). In step 406, the mobile terminal performs a DHCP message exchange with a DHCP server. In step 408, it is determined whether the DHCP message from the DHCP server includes a DHCP option (e.g., a Default WWW Server (WWW-Server) Option) indicating the IP address of a service discovery server. If it is determined that the address of a service discovery server is not included in a DHCP option in the DHCP message, the process may end. Otherwise, the process proceeds to step 410 where the mobile terminal sends a HTTP GET request to the IP address indicated in the DHCP option. In step 412, the mobile terminal receives a HTTP Response indicating a list of addresses and/or information relating to supported application servers and/or services. In step 414, the mobile terminal requests and starts using one or more of the services indicated in the HTTP Response, and the process may end.

[0062] FIG. 5 depicts a message format 500 for DHCPOFFER and/or DHCPACK message (e.g., indicated by a value of 2 in the op field 522, representing a reply) with a Default WWW Server Option 506 that may be sent by a DHCP server in response to a DHCPDISCOVER and/or DHCPREQUEST message from a communication apparatus, for example, a mobile terminal, a router, or an application host, according to various embodiments of the present disclosure. The length of each field in the DHCP message in octets is listed below the corresponding field in FIG. 5. The message format 500 may comprise an options field 502 including a DHCP Message Type Option field 504 and a Default WWW Server Option field 506. The DHCP Message Type Option field 504 is used to convey the type of the DHCP message. The code for this option is 53 (e.g., code field 508) and its length is 1 octet (e.g., len field 510). The type of the DHCP message is indicated by a value in the type field 512 according to the value-type pairs shown in table 520 (the value of 1 standing for DHCPDISCOVER message, the value of 2 standing for DHCPOFFER message, the value of 3 standing for DHCPREQUEST message, the value of 4 = standing for DHCPDECLINE message, the value of 5 standing for DHCPACK message, the value of 6 = standing for DHCPNAK message, the value of 7 = standing for DHCPRELEASE message, and the value of 8 = standing for DHCPINFORM message). The Default WWW Server Option field 506 specifies a list of one or more server addresses that are available to the client in the server address field 518. The servers may typically be listed in order of preference. The code for the Default WWW Server Option is 72 (e.g., indicated in code field 514). The minimum length for this option is 4 octets, and the length is always a multiple of 4 (e.g., a value of 4*N as indicated in len

field 516, where in N is the number of included server addresses and is an integer greater than 0).

[0063] FIG. 6 depicts a message format 600 for DHCPDISCOVER and/or DHCPREQUEST message (e.g., indicated by a value of 1 in the op field 622, representing a request) with a Parameter Request List Option that may be sent by a communication apparatus, for example, a mobile terminal, a router, or an application host, to a DHCP server according to various embodiments of the present disclosure. The length of each field in the DHCP message is listed below the corresponding field in FIG. 6. The message format 600 may comprise an options field 602 including a DHCP Message Type Option field 604 and a Parameter Request List Option field 606. The DHCP Message Type Option field 604 is used to convey the type of the DHCP message. The code for this option is 53 (e.g., code field 608) and its length is 1 (e.g., len field 610). The type of the DHCP message is indicated by a value in type field 612 as shown in table 520 in FIG. 5 (the value of 1 standing for DHCPDISCOVER message, the value of 2 standing for DHCPOFFER message, the value of 3 standing for DHCPREQUEST message, the value of 4 standing for DHCPDECLINE message, the value of 5 standing for DHCPACK message, the value of 6 standing for DHCPNAK message, the value of 7 standing for DHCPRELEASE message, and the value of 8 standing for DHCPINFORM message). The Parameter Request List Option field 606 is used by a DHCP client to request values for specified configuration parameters. The list of requested parameters is specified as n octets (n is an integer greater than 0), where each octet is a valid DHCP option code. In a variation or optional step, the Parameter Request List Option 606 in the sent DHCPDISCOVER and/or DHCPREQUEST may include code 72 to request the Default WWW Server Option from the DHCP server (e.g., option code field 618 with a value c1 = 72 to indicate the Default WWW Server Option). The client may list the options in order of preference. The DHCP server is not required to return the options in the requested order, but should insert the requested options in the order requested by the client. The code for this option is 55 (e.g., indicated in code field 614). The minimum length for this option is 1 octet (e.g., indicated in the len field 616).

[0064] FIG. 7 depicts a message format 700 for a list of addresses and/or information relating to services and/or servers according to various embodiments of the present disclosure. Message format 700 is an example of the content with the list of addresses and/or information relating to services and servers sent by a service discovery server to a communication apparatus, for example, a mobile terminal or an application host, in a HTTP response. In this example, there are

two application servers available to the communication apparatus, e.g., the mobile terminal, on a LAN2. The first application server (IP Address: 192.168.100.1) as described in message portion 702 is a file server which uses HTTPS protocol and may be used for file uploads. The second application server (IP Address: 192.168.200.1) as described in message portion 704 is a streaming server which uses RTSP protocol and may be used for accessing a camera live stream. Other information related to the services may also be included such as location and capabilities of a live streaming camera and content for download on a file server.

[0065] For illustration without limitation, FIG. 8 depicts a block diagram 800 of a mobile terminal (e.g., mobile terminal 102) according to an embodiment of the present disclosure. For example, the mobile terminal may comprise a transceiver 808 and circuitry 804. The mobile terminal may further comprise a memory module 802, and a secondary storage 806. In an instance, the transceiver 808 may be a wireless transceiver including one or more antennas and may be used for establishing a connection (e.g., LAN1) with an AP (e.g., AP 104 in FIG. 1). In an implementation, the mobile terminal 800 may be referred to as a communication apparatus comprising circuitry 804 and a communication interface, the communication interface being the transceiver 808.

[0066] FIG. 9 depicts a block diagram 900 of an AP with DHCP server function according to an embodiment of the present disclosure. In this embodiment, the AP and DHCP server may be collocated in a same apparatus (e.g., AP 104 and DHCP server 106 are collocated in the AP represented by block diagram 900). For example, the AP may comprise a transceiver 908 and circuitry 904. The AP may further comprise a memory module 902, a secondary storage 906, and a LAN interface 912. In an instance, the transceiver 908 may be a wireless transceiver including one or more antennas and may be used for establishing a connection (e.g., LAN1) with a mobile terminal (e.g., mobile terminal 102 in FIG. 1). The LAN interface 912 connects to a service discovery server (e.g., service discovery server 110 in FIG. 1) and/or an application server (e.g., application server 108 in FIG. 1) on a LAN2. The AP acts as a router to connect the wireless LAN (LAN1) and LAN2. In an implementation, LAN2 may be a wired or wireless LAN.

[0067] FIG. 10 depicts a block diagram 1000 of an application server with service discovery server function according to an embodiment of the present disclosure. In this embodiment, the service discovery server and application server may be collocated in a same apparatus (e.g., service discovery server 110 and application server 108 are collocated in the application server

represented by block diagram 1000). For example, the application server may comprise a memory module 1002, controller circuitry 1004, secondary storage 1006 and a LAN interface 1008. The LAN interface 1008 enables the application server to connect to an AP and/or a DHCP Server (e.g., a collocated AP 104 and DHCP server 106) on a LAN (e.g., LAN2). In an implementation, LAN2 may be a wired or wireless LAN.

[0068] In another embodiment, referring to system 1100 of FIG. 11, the mobile terminal from the above embodiment (mobile terminal 102 in Fig. 1) may be implemented as a mobile terminal 1102 and application host 1114 connected by a router 1112. For example, the mobile terminal 1102 and router 1112 may be connected using a wired ethernet connection (e.g., LAN3), and the router 1112 and application host 1114 may be connected using a wired ethernet connection (e.g., LAN4). LAN3 and LAN4 may have different subnets. The wireless AP 1104, DHCP server 1106, service discovery server 1110 and application server 1108 may be connected via a LAN2. One or more of the wireless AP 1104, DHCP server 1106, service discovery server 1110 and application server 1108 may be collocated on a same device and there may be one or more of each of these in the system. A typical case may be to collocate the wireless AP 1104 with the DHCP server 1106, in which case, the wireless AP 1104 acts as a router to connect the wireless LAN (e.g., LAN1 between mobile terminal 1102 and AP 1104) and the local area network (e.g., LAN2) which may be on different subnets. In another case, the wireless AP 1104 may act as a bridge to connect the wireless LAN (LAN1) and the local area network (LAN2) which may be on the same subnet or on a subnet with overlapping range of addresses (e.g., with network configuration using Proxy ARP). The mobile terminal 1102 may function as a network bridge. DHCP message exchange is between the router 1112 and the DHCP server 1106. The connection of application host 1114 to the router 1112 (LAN2) should be established prior to the wireless connection (LAN1). The router 1112 may also act as a DHCP server that provides IP addresses for hosts in LAN3 (e.g., application host 1114). The application host 1114 may obtain its IP address from the router 1112, for example, when the mobile terminal 1102 has not established the connection to the AP 1104 and the DHCP server 1106 is not accessible from the application host 1114. The application host 1112 receives a Default WWW Server Option containing the IP address of a service discovery server 1110 from the router 1114 and then proceeds with service discovery with the service discovery server 1110 using, for example, a HTTP request/response. In this embodiment, an application host on an in-vehicle network (e.g., LAN4) will advantageously be able to access services on LAN2 via the router and LAN1 connection with minimal delay upon connection of LAN1.

[0069] FIG. 12 depicts a message sequence chart 1200 corresponding to system 1100. Similar to the message sequence chart 200 of system 100, the wireless connection (e.g., LAN1) is established between the mobile terminal 1102 and the AP 1104 via association process 1202. Upon establishment of LAN1, the mobile terminal 1102 notifies the router 1112 (e.g., notification 1204), and the router 1112 performs the DHCP message sequence 1206 with the DHCP server 1106 via LAN1. Upon obtaining an IP address to be used for subsequent communication and the IP address of service discovery server 1110 (e.g., obtained from a Default WWW Server Option) from the DHCP server 1106, the router 1112 notifies the application host 1114 and informs the IP address of service discovery server 1110 (e.g., notification 1208 with WWW Server values). Upon receiving the notification 1208 with the service discovery server address, the application host 1114 proceeds to send a message, for example a HTTP GET request, to the service discovery server 1110 and receives a response, for example a HTTP response, containing a list of addresses and/or information relating to application servers and services that may be available on LAN2 (e.g., HTTP GET request and HTTP response message exchange 1210). The application host 1114 then proceeds to request and access one or more of the available application servers and services (e.g., Service request and service provision process 1212).

[0070] The notification 1204 between the mobile terminal 1102 and router 1112 as well as the notification 1208 between the router 1112 and application host 1114 may, for example, be implemented by one of the following methods:

- pub-sub type messaging using such as socket IO, websocket, MQTT, ZeroMQ, Kafka, AMQP, etc.
- producer-consumer messaging
- Event driven notification
- IP multicast
- Memory database with notification function (e.g., redis, etc.)
- File creation or modification
- Logging (e.g., syslogd, etc.)

Setup between the mobile terminal 1102 and router 1112 as well as between the router 1112 and application host 1114 may be required prior to establishing the wireless connection (LAN1).

[0071] FIG. 13 depicts a flowchart 1300 illustrating the behaviour of a mobile terminal (e.g., mobile terminal 1102) according to another embodiment of the present disclosure. The process starts at step 1302. In step 1304, the mobile terminal associates with an AP (e.g., AP 1104). In step 1306, after establishing a connection to the AP (e.g., LAN1), the mobile terminal notifies the router (e.g., router 1112) about the connection via, for example, a wired connection (e.g., LAN3).

[0072] FIG. 14 depicts a flowchart 1400 illustrating the behaviour of a router (e.g., router 1112) according to another embodiment of the present disclosure. The process starts at step 1402. In step 1404, a connection notification is received (e.g., from mobile terminal 1102). In step 1406, DHCP messages are exchanged with a server (e.g., DHCP server 1106). In step 1408, it is determined if the DHCP message from the server includes a DHCP option (e.g., a WWW-Server Option) indicating the IP address of a service discovery server. If it is determined to be so, the process proceeds to step 1412 where the connection and the service discovery server address(es) contained in the DHCP option (e.g., WWW-Server Option) are notified to an application host (e.g., application host 1114), and the process may end. Otherwise, the process proceeds to step 1410 instead where the connection is notified to the application host, and then the process may end.

[0073] FIG. 15 depicts a flowchart 1500 illustrating the behaviour of an application host (e.g., 1114) according to another embodiment of the present disclosure. The process starts at step 1502. In step 1504, a connection notification is received (e.g., from router 1112). In step 1506, it is determined if the notification includes a service discovery server address (e.g., address of the service discovery server 1110). If it is determined that there is no service discovery server address, the process may end. Otherwise, the process proceeds to step 1508 where a HTTP Request is sent to the service discovery server address (e.g., sent to the service discovery server 1110). In step 1510, a HTTP Response indicating one or more supported services and/or servers is received (e.g., from the service discovery server 1110). In step 1512, the application host starts using one or more of the services and/or servers indicated in the HTTP Response, and the process may end.

[0074] Fig. 16 depicts a block diagram 1600 of a mobile terminal (e.g., mobile terminal 1102) according to another embodiment of the present disclosure. For example, the mobile terminal may comprise a memory module 1602, controller circuitry 1804, secondary storage 1606, a transceiver 1608, and a LAN interface 1612. In an instance, the transceiver 1608 may be a

wireless transceiver including one or more antennas and may be used for establishing a connection (e.g., LAN1) with an AP (e.g., AP 1104). The LAN interface 1612 is used for connecting to the router (e.g., router 1112) on a LAN3. The mobile terminal acts as a network bridge between LAN1 and LAN3. In an implementation, LAN3 may be a wired or wireless LAN.

[0075] FIG. 17 depicts a block diagram 1700 of a router (e.g., router 1112) according to another embodiment of the present disclosure. For example, the router may comprise a memory module 1702, controller circuitry 1704, secondary storage 1706 and N LAN interfaces 1708. The router includes (in N LAN interfaces 1708) at least two LAN interfaces for connection to a mobile terminal (e.g., mobile terminal 1102 via LAN3) and application host (e.g., application host 1114 via LAN4). In an implementation, LAN3 and/or LAN4 may be a wired or wireless LAN.

[0076] FIG. 18 depicts a block diagram of an application host 1800 (e.g., application host 1114) according to another embodiment of the present disclosure. For example, the application host may comprise a memory module 1802, controller circuitry 1804, secondary storage 1806 and a LAN interface 1808. The LAN interface 1808 enables the application host to connect to a router (e.g., router 1112) on a LAN (e.g., LAN4). In an implementation, LAN4 may be a wired or wireless LAN. In an implementation, the application host 1800 may be referred to as a communication apparatus comprising circuitry 1804 and a communication interface, the communication interface being the LAN interface 1808.

[0077] In yet another embodiment, referring to system 1900 of FIG. 19, the mobile terminal in the above embodiment (mobile terminal 102 in Fig. 1) may be implemented as a mobile terminal 1902 and application host 1912. In addition to providing a wireless connection with AP 1904 (e.g., LAN1), the mobile terminal 1902 acts as a router for the application host 1912. For example, the mobile terminal 1902 and application host 1912 may be connected using a wired ethernet connection (e.g., LAN3). LAN1 and LAN3 may have different subnets. The wireless AP 1904, DHCP server 1906, service discovery server 1910 and application server 1908 are connected via a LAN2. One or more of the wireless AP 1904, DHCP server 1906, service discovery server 1910 and application server 1908 may be collocated on a same device and there may be one or more of each of these in the system. A typical case may be to collocate the wireless AP 1904 with the DHCP server1906, in which case, the wireless AP 1904 acts as a router to connect the wireless LAN (e.g., LAN1 between mobile terminal 1902 and AP 1904) and the local area network (e.g., LAN2) which may be on different subnets. In another case, the wireless AP 1904 may act as a

bridge to connect the wireless LAN (LAN1) and the local area network (LAN2) which may be on the same subnet or on a subnet with overlapping range of addresses (e.g., with network configuration using Proxy ARP). DHCP message exchange is between the mobile terminal 1902 and DHCP server 1906. The application host 1912 receives Default WWW Server Option from the mobile terminal 1902 and then proceeds with service discovery with service discovery server 1908 using, for example, a HTTP request/response. In this embodiment, an application host on an in-vehicle network (e.g., LAN3) will advantageously be able to access services on LAN2 via the mobile terminal 1902 and LAN1 connection with minimal delay upon connection of LAN1.

[0078] FIG. 20 depicts a message sequence chart 2000 corresponding to system 1900. Similar to the message sequence chart 200 of system 100, the wireless connection (e.g., LAN1) is established between the mobile terminal 1902 and the AP 1904 via association process 2002. Upon establishment of LAN1, the mobile terminal 1902 performs the DHCP message sequence 2006 with the DHCP server 1906 via LAN1. Upon obtaining an IP address to be used for subsequent communication and the IP address of service discovery server 1910 (e.g., obtained from a Default WWW Server Option) from the DHCP server 1906, the mobile terminal 1902 notifies the application host 1912 and informs the IP address of service discovery server 1910 (e.g., notification 2008 with WWW Server values). Upon receiving the notification 2008 with the service discovery server address, the application host 1912 proceeds to send a message, for example a HTTP GET request, to the service discovery server 1910 and receives a response, for example a HTTP response, containing a list of addresses and/or information relating to application servers and services that may be available on LAN2 (e.g., HTTP GET request and HTTP response message exchange 2010). The application host 1912 then proceeds to request and access one or more of the available application servers and services (e.g., Service request and service provision process 2012).

[0079] The notification 2008 between the mobile terminal 1902 and application host 1912 may, for example, be one of the following methods:

- pub-sub type messaging using such as socket IO, websocket, MQTT, ZeroMQ, Kafka, AMQP, etc.
- producer-consumer messaging
- Event driven notification
- IP multicast

- Memory database with notification function (e.g., redis, etc.)
- File creation or modification
- Logging (e.g., syslogd, etc.)

Setup between the mobile terminal 1902 and application host 1912 may be required prior to establishing the wireless connection (LAN1).

[0080] FIG. 21 depicts a flowchart 2100 illustrating the behaviour of a mobile terminal (e.g., mobile terminal 1902) according to the yet another embodiment of the present disclosure. The process starts at step 2102. In step 2104, the mobile terminal associates with an AP (e.g., AP 1904). In step 2106, after establishing a connection to the AP (e.g., LAN1), DHCP messages are exchanged with a server (e.g., DHCP server 1906). In step 2108, it is determined if the DHCP message from the server includes a DHCP option (e.g., a WWW-Server Option) indicating the IP address of a service discovery server. If it is determined to be so, the process proceeds to step 2112 where the connection and the service discovery server address(es) contained in the DHCP option are notified to an application host (e.g., application host 1912), and the process may end. Otherwise, the process proceeds to step 2110 instead where the connection is notified to the application host, and then the process may end. In a variation, the mobile terminal may skip notifying the connection to the application host if the DHCP message did not include the DHCP option with a service discovery server address.

[0081] FIG. 22 depicts a flowchart 2200 illustrating the behaviour of an application host (e.g., 1912) according to the yet another embodiment of the present disclosure. The process starts at step 2202. In step 2204, a connection notification is received (e.g., from mobile terminal 1902). In step 2206, it is determined if the notification includes a service discovery server address (e.g., address of the service discovery server 1910). If it is determined that there is no service discovery server address, the process may end. Otherwise, the process proceeds to step 2208 where a HTTP Request is sent to the service discovery server address (e.g., sent to the service discovery server 1910). In step 2210, a HTTP Response indicating one or more supported services and/or servers is received (e.g., from the service discovery server 1910). In step 2212, the application host starts using one or more of the services and/or servers indicated in the HTTP Response, and the process may end.

[0082] Fig. 23 depicts a block diagram 2300 of a mobile terminal (e.g., mobile terminal 1902) according to the yet another embodiment of the present disclosure. For example, the mobile

terminal may comprise a memory module 2302, controller circuitry 2304, secondary storage 2306, a transceiver 2308, and a LAN interface 2312. In an instance, the transceiver 2308 may be a wireless transceiver including one or more antennas and may be used for establishing a connection (e.g., LAN1) with an AP (e.g., AP 1904). The LAN interface 2312 is used for connecting to the application host (e.g., application host 1912) on a LAN3. The mobile terminal acts as a router for the application host. In an implementation, LAN3 may be a wired or wireless LAN.

[0083] FIG. 24 depicts a block diagram of an application host 2400 (e.g., application host 1912) according to the yet another embodiment of the present disclosure. For example, the application host may comprise a memory module 2402, controller circuitry 2404, secondary storage 2406 and a LAN interface 2408. The LAN interface 2408 enables the application host to connect to a mobile terminal (e.g., mobile terminal 1902) on a LAN (e.g., LAN3). In an implementation, LAN2 may be a wired or wireless LAN. In an implementation, the application host 2400 may be referred to as a communication apparatus comprising circuitry 2404 and a communication interface, the communication interface being the LAN interface 2408.

[0084] In still yet another embodiment, referring to system 2500 of FIG. 25, the mobile terminal in the above embodiment (mobile terminal 102 in Fig. 1) may be implemented as a mobile terminal 2502 and application host 2512. In addition to providing a wireless connection with AP 2504 (e.g., LAN1), the mobile terminal 2502 acts as a network bridge for the application host 2512. For example, the mobile terminal 2502 and application host 2512 may be connected using a wired ethernet connection (e.g., LAN3). The mobile terminal 2502 may act as a network bridge, such that LAN1 and LAN3 may have the same subnet. The wireless AP 2504, DHCP server 2506, service discovery server 2510 and application server 2508 are connected via a LAN2. One or more of the wireless AP 2504, DHCP server 2506, service discovery server 2510 and application server 2508 may be collocated on a same device and there may be one or more of each of these in the system. The wireless AP 2504 acts as a bridge to connect the wireless LAN (LAN1) and the local area network (LAN2) which may be on the same subnet. In an implementation, the wireless AP 2504 may also act as a network bridge, such that LAN1 and LAN2 may also have the same subnet. DHCP message exchange is between the application host 2512 and DHCP server 2506. The application host 2512 receives Default WWW Server Option from the DHCP server 2506 and then proceeds with service discovery with service discovery server 2508 using, for example, a HTTP request/response. In this embodiment, an application host on an in-vehicle

network (e.g., LAN3) will advantageously be able to access services on LAN2 via the mobile terminal 1902 and LAN1 connection with minimal delay upon connection of LAN1. In a variation, the application host 2512 may act as a router for other connected components.

[0085] FIG. 26 depicts a message sequence chart 2600 corresponding to system 2500. Similar to the message sequence chart 200 of system 100, the wireless connection (e.g., LAN1) is established between the mobile terminal 2502 and the AP 2504 via association process 2602. Upon establishment of LAN1, the mobile terminal 2502 notifies the application host 2512 about the connection via notification 2604. The application host 2512 performs the DHCP message sequence 2606 with the DHCP server 2506 via LAN1. Upon obtaining an IP address to be used for subsequent communication and the IP address of service discovery server 2510 (e.g., obtained from a Default WWW Server Option) from the DHCP server 2506, the application host 2512 proceeds to send a message, for example a HTTP GET request, to the service discovery server 2510 and receives a response, for example a HTTP response, containing a list of addresses and/or information relating to application servers and services that may be available on LAN2 (e.g., HTTP GET request and HTTP response message exchange 2610). The application host 2512 then proceeds to request and access one or more of the available application servers and services (e.g., Service request and service provision process 2612).

[0086] The notification between the mobile terminal 2502 and application host 2512 may, for example, be one of the following methods:

- pub-sub type messaging using such as socket IO, websocket, MQTT, ZeroMQ, Kafka, AMQP, etc.
- producer-consumer messaging
- Event driven notification
- IP multicast
- Memory database with notification function (e.g., redis, etc.)
- File creation or modification
- Logging (e.g., syslogd, etc.)

Setup between the mobile terminal 2502 and application host 2512 may be required prior to establishing the wireless connection (LAN1).

[0087] FIG. 27 depicts a flowchart 2700 illustrating the behaviour of a mobile terminal (e.g., mobile terminal 2502) according to the still yet another embodiment of the present disclosure. The

process starts at step 2702. In step 2704, the mobile terminal associates with an AP (e.g., AP 2504). In step 2706, after establishing a connection to the AP (e.g., LAN1), the mobile terminal notifies the application host (e.g., connection notification 2604 to application host 2512) about the connection via, for example, a wired connection (e.g., LAN3).

[0088] FIG. 28 depicts a flowchart 2800 illustrating the behaviour of an application host (e.g., application host 2512) according to the still yet another embodiment of the present disclosure. The process starts at step 2802. In step 2804, the application host receives the connection notification (e.g., notification 2804 in step 2906). In step 2806, after receiving the connection notification, DHCP messages are exchanged with a server (e.g., DHCP server 2506). In step 2808, it is determined if the DHCP message from the server includes a DHCP option (e.g., a WWW-Server) indicating the IP address of a service discovery server (e.g., an address of the service discovery server 2510). If it is determined that the address of a service discovery server is not included in a DHCP option in the DHCP message, the process may end. Otherwise, the process proceeds to step 2810 where a HTTP Request is sent to the service discovery server address (e.g., sent to the service discovery server 2510). In step 2812, a HTTP Response indicating one or more supported services and/or servers is received (e.g., from the service discovery server 2510). In step 2814, the application host starts using one or more of the services and/or servers indicated in the HTTP Response, and the process may end.

[0089] Fig. 29 depicts a block diagram 2900 of a mobile terminal (e.g., mobile terminal 2502) according to the still yet another embodiment of the present disclosure. For example, the mobile terminal may comprise a memory module 2902, controller circuitry 2904, secondary storage 2906, a transceiver 2908, and a LAN interface 2912. In an instance, the transceiver 2908 may be a wireless transceiver including one or more antennas and may be used for establishing a connection (e.g., LAN1) with an AP (e.g., AP 2504). The LAN interface 2912 is used for connecting to the application host (e.g., application host 2512) on a LAN3. The mobile terminal acts as a network bridge for the application host. In an implementation, LAN3 may be a wired or wireless LAN. In another implementation, the mobile terminal 2900 may be referred to as a communication apparatus comprising circuitry 2904 and a communication interface, the communication interface being the transceiver 2908.

[0090] FIG. 30 depicts a block diagram of an application host (e.g., application host 2512) according to the still yet another embodiment of the present disclosure. For example, the

application host may comprise a memory module 3002, controller circuitry 3004, secondary storage 3006 and a LAN interface 3008. The LAN interface 3008 enables the application host to connect to a mobile terminal (e.g., mobile terminal 2502) on a LAN (e.g., LAN3). In an implementation, LAN3 may be a wired or wireless LAN.

[0091] FIG. 31 shows a flow diagram 3100 illustrating a communication method according to various embodiments. At step 3102, messages are exchanged with a DHCP server via a first LAN. At step 3104, communication is established with a service discovery server is based on an address of the service discovery server indicated by a message from the DHCP server.

[0092] FIG. 32 shows a schematic, partially sectioned view of a communication apparatus 3200 that can be implemented for service discovery for local area network in accordance with the various embodiments. The communication apparatus 3200 may be implemented as a mobile terminal, application host, router, server, STA or AP according to various embodiments.

[0093] Various functions and operations of the communication apparatus 3200 are arranged into layers in accordance with a hierarchical model. In the model, lower layers report to higher layers and receive instructions therefrom in accordance with IEEE specifications. For the sake of simplicity, details of the hierarchical model are not discussed in the present disclosure.

[0094] As shown in Fig. 32, the communication apparatus 3200 may include circuitry 3214, at least one radio transmitter 3202, at least one radio receiver 3204 and multiple antennas 3212 (for the sake of simplicity, only one antenna is depicted in Fig. 32 for illustration purposes). The circuitry may include at least one controller 3206 for use in software and hardware aided execution of tasks it is designed to perform, including control of communications with one or more other devices in a wireless network. The at least one controller 3206 may control at least one transmission signal generator 3208 for generating frames to be sent through the at least one radio transmitter 3202 to one or more other STAs or APs and at least one receive signal processor 3210 for processing frames received through the at least one radio receiver 3204 from the one or more other STAs or APs. The at least one transmission signal generator 3208 and the at least one receive signal processor 3210 may be stand-alone modules of the communication apparatus 3200 that communicate with the at least one controller 3206 for the above-mentioned functions. Alternatively, the at least one transmission signal generator 3208 and the at least one receive signal processor 3210 may be included in the at least one controller 3206. It is appreciable to those skilled in the art that the arrangement of these functional modules is flexible and may vary

depending on the practical needs and/or requirements. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. It will be appreciated that a transceiver or a communication interface of the communication apparatus 3200 comprises the transmitter 3202 and the receiver 3204. The communication interface may further comprise a LAN interface.

[0095] In various embodiments, when in operation, the at least one radio transmitter 3202, at least one radio receiver 3204, and at least one antenna 3212 may be controlled by the at least one controller 3206. Furthermore, while only one radio transmitter 3202 is shown, it will be appreciated that there can be more than one of such transmitters.

[0096] In various embodiments, when in operation, the at least one radio receiver 3204, together with the at least one receive signal processor 3210, forms a receiver of the communication apparatus 3200. The receiver of the communication apparatus 3200, when in operation, provides functions required for processing an information container. While only one radio receiver 3204 is shown, it will be appreciated that there can be more than one of such receivers.

[0097] The communication apparatus 3200, when in operation, provides functions required for service discovery for local area network. For example, the transceiver may, in operation, exchange messages with a Dynamic Host Configuration Protocol (DHCP) server via a first local area network (LAN); and communicate with a service discovery server based on an address of the service discovery server indicated by a message from the DHCP server.

[0098] The circuitry 3214 may, in operation, be configured to determine the address of the service discovery server from the message from the DHCP server, wherein the transceiver is further configured to receive a response indicating a list of addresses and/or information relating to application servers and/or their services from the service discovery server. The transceiver may be further configured to: transmit a message, e.g., a GET Request, to the address of the service discovery server; receive, from the service discovery server in response to the GET Request, the response indicating the list of addresses and/or information relating to application servers and/or their services that are available in a second LAN; and transmit a service request to a service or server that is indicated in the list of services and servers. The service request may include a request for server and/or client authentication. The circuitry 3214 may be further configured to generate the GET Request indicating one or more desired services and/or one or more

capabilities of the communication apparatus, wherein the list of addresses and/or information relating to application servers and/or their services is based on the indicated one or more desired services and/or one or more capabilities.

[0099] The circuitry 3214 may, in operation, generate a DHCPDISCOVER message to discover the DHCP server, wherein the transceiver may be further configured to transmit the DHCPDISCOVER message to the DHCP server prior to receiving the message from the DHCP server, the message from the DHCP server indicating the address of the service discovery server in a DHCP option, e.g., a Default WWW Server Option. The DHCPDISCOVER message may comprise a Parameter Request List Option field indicating a request for the DHCP option indicating the address of the service discovery server from the DHCP server.

[00100] The communication apparatus 3200 may comprise a mobile terminal and an application host that are connected via a router, the mobile terminal comprising the transceiver. The router may be configured to provide the address of the service discovery server obtained from the DHCP option in the message from the DHCP server to the application host, and the application host may be configured to: transmit, via the transceiver and router, a message, e.g., a GET Request, to the indicated address of the service discovery server; receive, via the transceiver and router, a list of addresses and/or information relating to application servers and/or their services that are available in a second LAN in response to the GET Request; and transmit, via the transceiver and router, a service request to a service or server that is indicated in the list.

[00101] The communication apparatus 3200 may comprise a mobile terminal and an application host, the mobile terminal comprising the transceiver. The mobile terminal may be configured to provide the address of the service discovery server obtained from the DHCP option in the message from the DHCP server to the application host, and the application host may be configured to: transmit, via the transceiver, a message, e.g., a GET Request, to the indicated address of the service discovery server; receive, via the transceiver, a list of addresses and/or information relating to application servers and/or their services that are available in a second LAN in response to the GET Request; and transmit, via the transceiver, a service request to a service or server that is indicated in the list.

[00102] The transceiver may comprise a LAN interface communicating via a mobile terminal (e.g. for a LAN interface). The transceiver may be configured: to transmit, via the mobile

terminal, a message, e.g., a GET Request, to the indicated address of the service discovery server; and receive, via the mobile terminal, a list of addresses and/or information relating to application servers and/or their services that are available in a second LAN in response to the GET Request. The transceiver may be configured to transmit, via the mobile terminal, a service request to a service or server that is indicated in the list.

[00103] For example, the communication apparatus 3200 may comprise a communication interface and circuitry 3214. The circuitry 3214 may acquire, via the communication interface, a list of at least one application service from a service discovery server, and request an application service based on the list. The circuitry 3214 may be further configured to acquire, via the communication interface, an address of the service discovery server from a DHCP server directly or via a mobile terminal or a router.

[00104] The present disclosure can be realized by software, hardware, or software in cooperation with hardware. Each functional block used in the description of each embodiment described above can be partly or entirely realized by an integrated circuit (IC) such as LSI (Large Scale Integration), and each process described in each embodiment may be controlled partly or entirely by a same LSI or a combination of LSIs. The LSI may be individually formed as chips, or one chip may be formed so as to include a part or all of the functional blocks. The LSI may include a data input and output coupled thereto. The LSI here may be referred to as an IC, a system LSI, a super LSI, an ultra-LSI, a very-large-scale integration (VLSI), or a system on a chip (SoC) depending on the integration scales. However, the technique of implementing an integrated circuit is not limited to the LSI and may be realized by using a dedicated circuit, a general-purpose processor, or a special-purpose processor. In addition, a FPGA (Field Programmable Gate Array) that can be programmed after the manufacture of the LSI or a reconfigurable processor in which the connections and the settings of circuit cells disposed inside the LSI can be reconfigured may be used. The present disclosure can be realized as digital processing and/or analogue processing. The functional blocks could be integrated with various integrated circuit technologies which are not limited to those mainly used at present. Biotechnology can also be applied.

[00105] The present disclosure can be realized by any kind of apparatus, device or system having a function of communication, which is referred to as a communication apparatus.

[00106] Some non-limiting examples of such communication apparatus may include a phone (e.g., cellular (cell) phone, smart phone), a tablet, a personal computer (PC) (e.g., laptop, desktop, netbook), a camera (e.g., digital still/video camera), a digital player (digital audio/video player), a wearable device (e.g., wearable camera, smart watch, tracking device, head mounted display (HMD), smart glasses), a game console, a digital book reader, a telehealth/telemedicine (remote health and medicine) device, and a vehicle providing communication functionality (e.g., automotive, airplane, ship), and various combinations thereof.

[00107] The communication apparatus is not limited to be portable or movable, and may also include any kind of apparatus, device or system being non-portable or stationary, such as a smart home device (e.g., an appliance, lighting, smart meter, control panel), a vending machine, and any other “things” in a network of an “Internet of Things (IoT)”.

[00108] The communication may include exchanging data through, for example, a cellular system, a wireless LAN system, a satellite system, etc., and various combinations thereof.

[00109] The communication apparatus may comprise a device such as a controller or a sensor which is coupled to a communication apparatus performing a function of communication described in the present disclosure. For example, the communication apparatus may comprise a controller or a sensor that generates control signals or data signals which are used by a communication apparatus performing a communication function of the communication apparatus.

[00110] The communication apparatus also may include an infrastructure facility, such as a base station, an access point, and any other apparatus, device or system that communicates with or controls apparatuses such as those in the above non-limiting examples.

[00111] Thus, it can be seen that the present embodiments provide communication apparatuses and methods for service discovery for local area network.

[00112] While exemplary embodiments have been presented in the foregoing detailed description of the present embodiments, it should be appreciated that a vast number of variations exist. It should further be appreciated that the exemplary embodiments are examples, and are not intended to limit the scope, applicability, operation, or configuration of this disclosure in any way. Rather, the foregoing detailed description will provide those skilled in the art with a

convenient road map for implementing exemplary embodiments, it being understood that various changes may be made in the function and arrangement of steps and method of operation described in the exemplary embodiments and modules and structures of devices described in the exemplary embodiments without departing from the scope of the subject matter as set forth in the appended claims.

CLAIMS

1. A communication apparatus, comprising:
a transceiver, which in operation, is configured to:
exchange messages with a Dynamic Host Configuration Protocol (DHCP) server via a first local area network (LAN); and
communicate with a service discovery server based on an address of the service discovery server indicated by a message from the DHCP server.

2. The communication apparatus of claim 1, further comprising circuitry, which in operation, is configured to determine the address of the service discovery server from the message from the DHCP server, wherein the transceiver is further configured to receive a response indicating a list of addresses and/or information relating to application servers and/or their services from the service discovery server.

3. The communication apparatus of claim 1, further comprising circuitry, which in operation, generates a DHCPDISCOVER message to discover the DHCP server, wherein the transceiver is further configured to transmit the DHCPDISCOVER message to the DHCP server prior to receiving the message from the DHCP server, the message from the DHCP server indicating the address of the service discovery server in a DHCP option.

4. The communication apparatus of claim 3, wherein the DHCP option indicating the address of the service discovery server is a Default World Wide Web (WWW) Server Option.

5. The communication apparatus of claim 3, wherein the DHCPDISCOVER message comprises a Parameter Request List Option field indicating a request for the DHCP option indicating the address of the service discovery server from the DHCP server.

6. The communication apparatus of claim 2, wherein the transceiver is further configured to:
transmit a GET Request to the address of the service discovery server;
receive, from the service discovery server in response to the GET Request, the response indicating the list of addresses and/or information relating to application servers and/or their services that are available in a second LAN; and

transmit a service request to a service or server that is indicated in the list of services and servers.

7. The communication apparatus of claim 6, wherein the service request includes a request for server and/or client authentication.

8. The communication apparatus of claim 6, wherein the circuitry is further configured to generate the GET Request indicating one or more desired services and/or one or more capabilities of the communication apparatus, wherein the list of addresses and/or information relating to application servers and/or their services is based on the indicated one or more desired services and/or one or more capabilities.

9. The communication apparatus of claim 3, wherein the communication apparatus comprises a mobile terminal and an application host that are connected via a router, the mobile terminal comprising the transceiver.

10. The communication apparatus of claim 9, wherein the router is configured to provide the address of the service discovery server indicated in the DHCP option received from the DHCP server to the application host, and the application host is configured to:

transmit, via the transceiver and router, a GET Request to the indicated address of the service discovery server;

receive, via the transceiver and router, a list of addresses and/or information relating to application servers and/or their services that are available in a second LAN in response to the GET Request; and

transmit, via the transceiver and router, a service request to a service or server that is indicated in the list.

11. The communication apparatus of claim 3, wherein the communication apparatus comprises a mobile terminal and an application host, the mobile terminal comprising the transceiver.

12. The communication apparatus of claim 11, wherein the mobile terminal is configured to provide the address of the service discovery server indicated in the DHCP option

received from the DHCP server to the application host, and the application host is configured to:

transmit, via the transceiver, a GET Request to the indicated address of the service discovery server;

receive, via the transceiver, a list of addresses and/or information relating to application servers and/or their services that are available in a second LAN in response to the GET Request; and

transmit, via the transceiver, a service request to a service or server that is indicated in the list.

13. The communication apparatus of claim 3, wherein the transceiver comprises a LAN interface communicating via a mobile terminal.

14. The communication apparatus of claim 13, wherein the transceiver is configured: to transmit, via the mobile terminal, a GET Request to the indicated address of the service discovery server; and receive, via the mobile terminal, a list of addresses and/or information relating to application servers and/or their services that are available in a second LAN in response to the GET Request.

15. The communication apparatus of claim 15, wherein the transceiver is configured to transmit, via the mobile terminal, a service request to a service or server that is indicated in the list.

16. A communication method, comprising:

exchanging messages with a DHCP server via a first LAN; and

communicating with a service discovery server based on an address of the service discovery server indicated by a message from the DHCP server.

17. The communication method of claim 16, further comprising:

determining the address of the service discovery server from the message from the DHCP server, and

receiving a response indicating a list of addresses and/or information relating to application servers and/or their services from the service discovery server.

18. A communication apparatus, comprising:

a communication interface; and

circuitry, which in operation, acquires, via the communication interface, a list of at least one application service from a service discovery server, and requests an application service based on the list.

19. The communication apparatus according to claim 18,

wherein the circuitry is further configured to acquire, via the communication interface, an address of the service discovery server from a DHCP server directly or via a mobile terminal or a router.