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Montemurro et al.

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(54) **METHODS AND APPARATUS TO DISCOVER NETWORK CAPABILITIES AVAILABLE VIA WIRELESS NETWORKS**

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(51) **Int. Cl.**

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H04W 84/12	(2009.01)
H04L 29/08	(2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H04W 48/16*** (2013.01); ***H04L 67/16*** (2013.01); ***H04W 8/22*** (2013.01); ***H04W 48/20*** (2013.01); ***H04W 84/12*** (2013.01)

(58) **Field of Classification Search**

CPC H04W 48/16; H04W 84/12; H04W 8/22; H04W 48/20; H04L 67/16

USPC 370/328–332, 338

See application file for complete search history.

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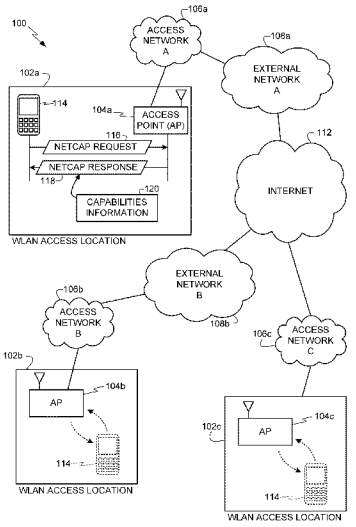
(57) **ABSTRACT**

An example method for network selection involves discovering network capabilities by performing an Access Network Query Protocol (ANQP) query at a wireless terminal, and receiving a subsequent ANQP response from an access point of a wireless local area network. The network capabilities are indicated in the subsequent ANQP response. The example method also involves comparing the network capabilities with configured capabilities, finding a match between at least a portion of the network capabilities and at least a portion of the configured capabilities, and joining the wireless terminal with the access point based on the at least the portion of the network capabilities matching the at least the portion of the configured capabilities.

15 Claims, 11 Drawing Sheets



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H04W 8/22 (2009.01)
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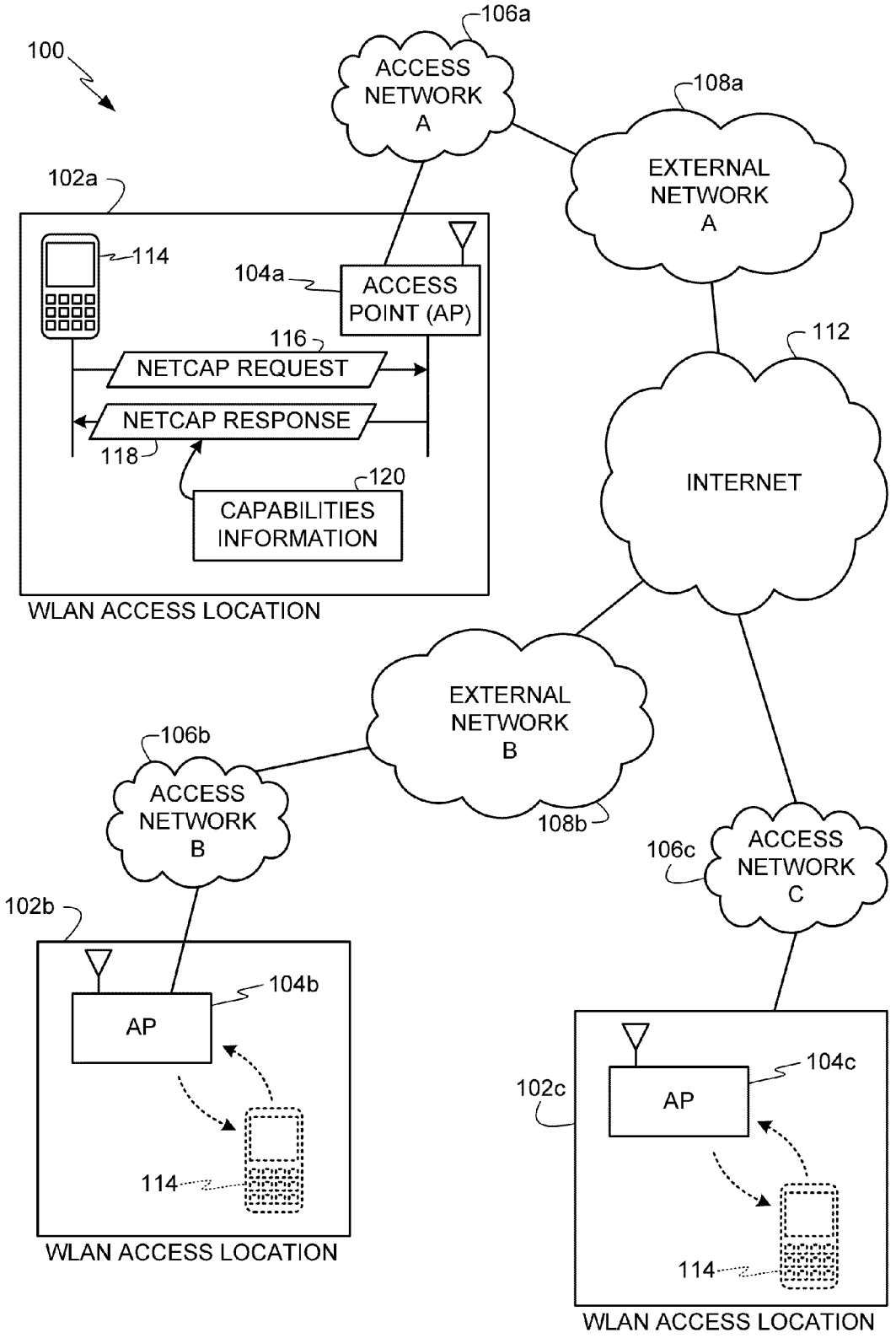

100
106a
ACCESS NETWORK A
108a
EXTERNAL NETWORK A
102a
114
104a
ACCESS POINT (AP)
116
NETCAP REQUEST
NETCAP RESPONSE
118
120
CAPABILITIES INFORMATION
WLAN ACCESS LOCATION
112
INTERNET
EXTERNAL NETWORK B
106b
ACCESS NETWORK B
108b
106c
ACCESS NETWORK C
102b
AP
104b
114
WLAN ACCESS LOCATION
102c
AP
104c
114
WLAN ACCESS LOCATION

FIG. 1

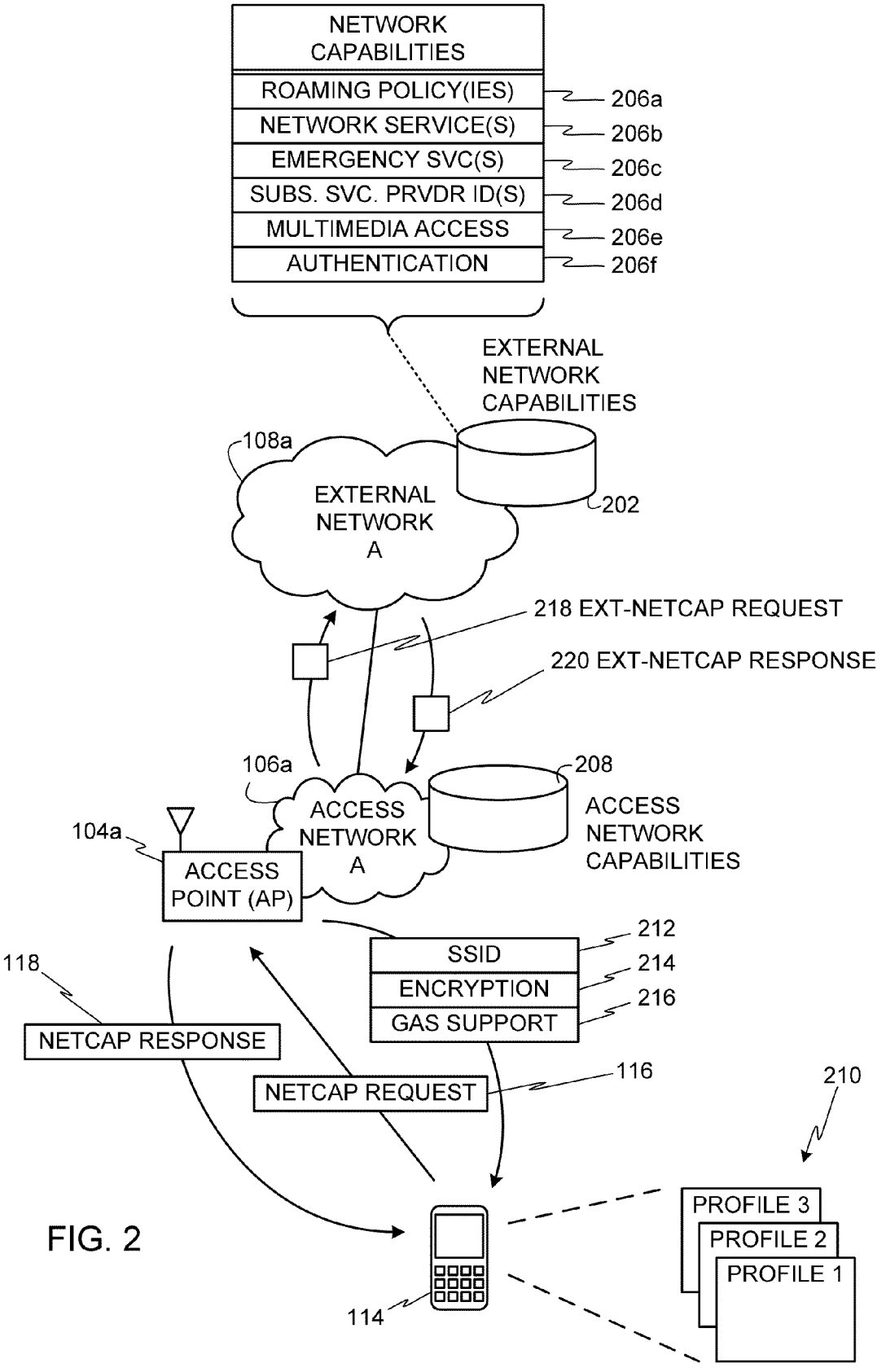
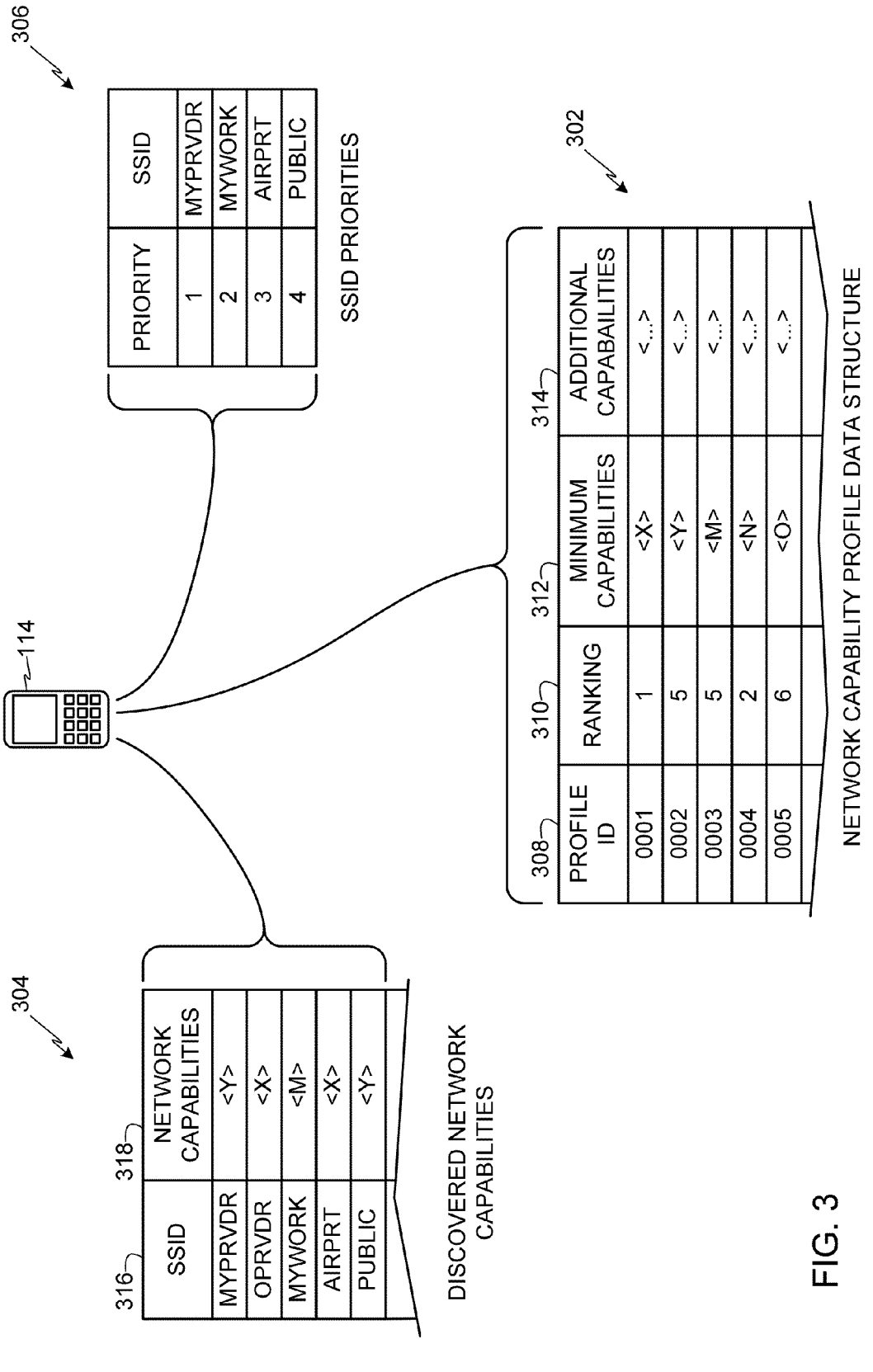

NETWORK CAPABILITIES
ROAMING POLICY(IES)
NETWORK SERVICE(S)
EMERGENCY SVC(S)
SUBS. SVC. PRVDR ID(S)
MULTIMEDIA ACCESS
AUTHENTICATION
206a
206b
206c
206d
206e
206f
EXTERNAL NETWORK CAPABILITIES
108a
EXTERNAL NETWORK A
202
218 EXT-NETCAP REQUEST
220 EXT-NETCAP RESPONSE
106a
208
ACCESS NETWORK A
ACCESS NETWORK CAPABILITIES
104a
ACCESS POINT (AP)
212
SSID
214
ENCRYPTION
216
GAS SUPPORT
118
NETCAP RESPONSE
NETCAP REQUEST
116
210
PROFILE 3
PROFILE 2
PROFILE 1
114

FIG. 2


306
PRIORITY
SSID
1
MYPRVDR
2
MYWORK
3
AIRPRT
4
PUBLIC
SSID PRIORITIES
114
302
314
ADDITIONAL CAPABILITIES
312
MINIMUM CAPABILITIES
310
RANKING
308
PROFILE ID
0001
1
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<...>
0002
5
<Y>
<...>
0003
5
<M>
<...>
0004
2
<N>
<...>
0005
6
<O>
<...>
NETWORK CAPABILITY PROFILE DATA STRUCTURE
304
318
NETWORK CAPABILITIES
316
SSID
MYPRVDR
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OPRVDR
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MYWORK
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AIRPRT
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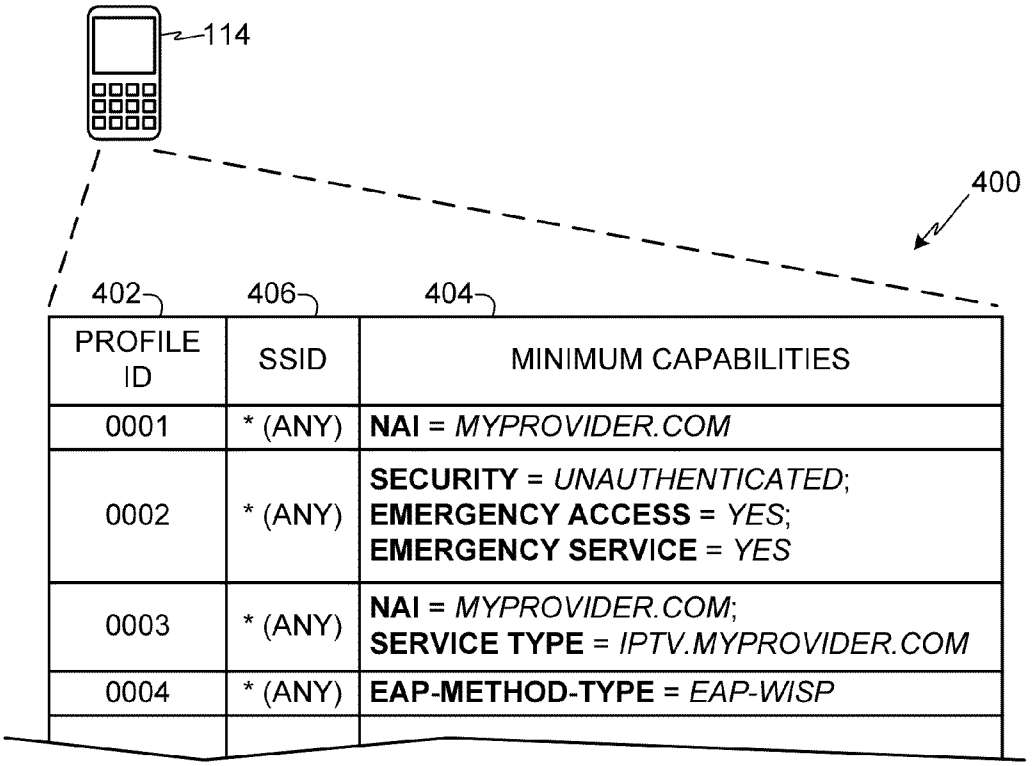
PUBLIC
<Y>
DISCOVERED NETWORK CAPABILITIES

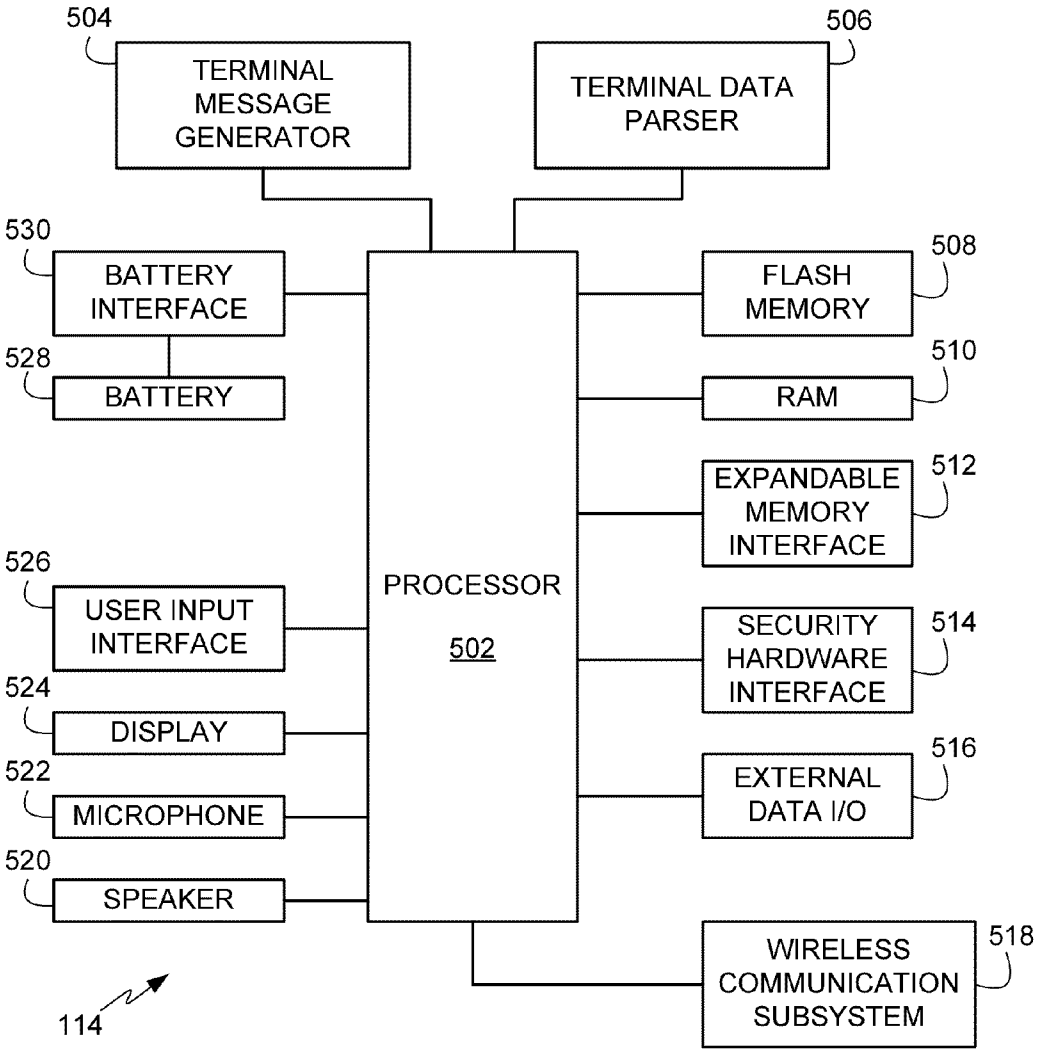
FIG. 3



PROFILE ID	SSID	MINIMUM CAPABILITIES
0001	* (ANY)	**NAI** = *MYPROVIDER.COM*
0002	* (ANY)	**SECURITY** = *UNAUTHENTICATED*; **EMERGENCY ACCESS** = *YES*; **EMERGENCY SERVICE** = *YES*
0003	* (ANY)	**NAI** = *MYPROVIDER.COM*; **SERVICE TYPE** = *IPTV.MYPROVIDER.COM*
0004	* (ANY)	**EAP-METHOD-TYPE** = *EAP-WISP*

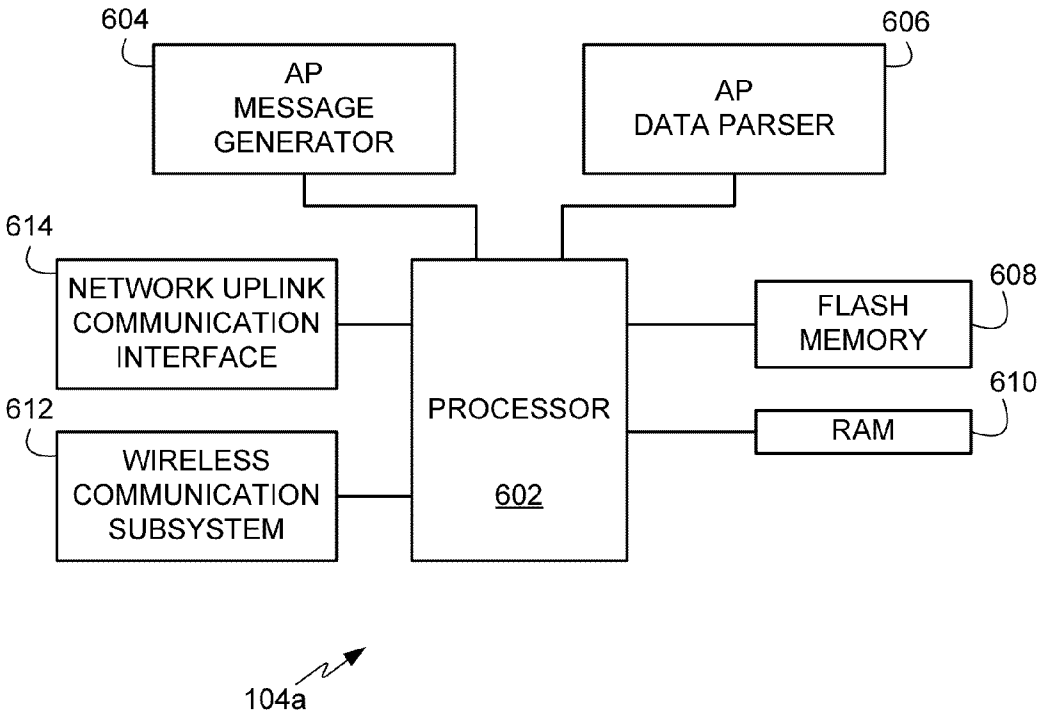
NETWORK CAPABILITY PROFILE DATA STRUCTURE

FIG. 4



WIRELESS TERMINAL

FIG. 5



ACCESS POINT

FIG. 6

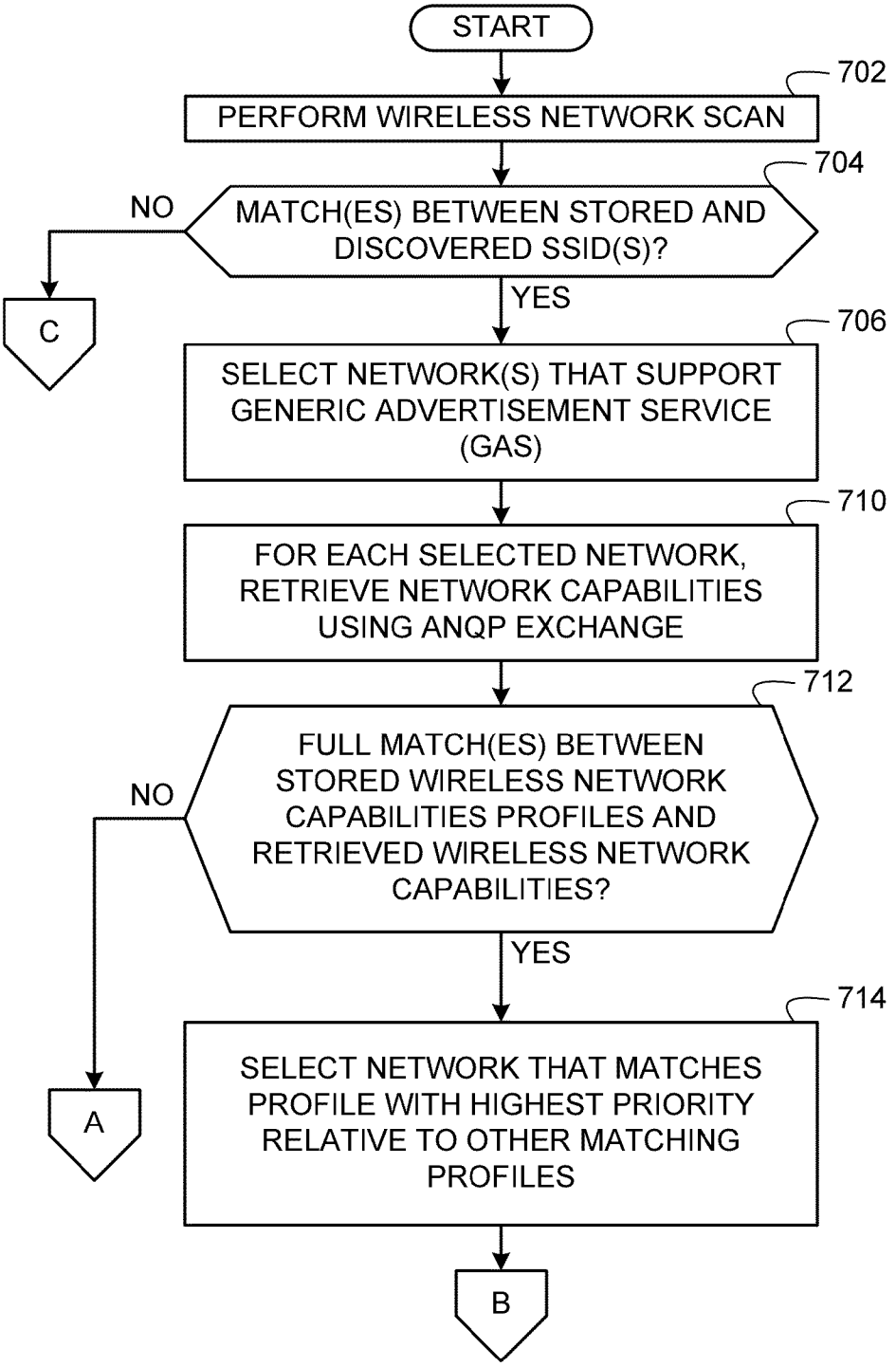

START
PERFORM WIRELESS NETWORK SCAN
702
MATCH(ES) BETWEEN STORED AND DISCOVERED SSID(S)?
704
NO
YES
C
SELECT NETWORK(S) THAT SUPPORT GENERIC ADVERTISEMENT SERVICE (GAS)
706
FOR EACH SELECTED NETWORK, RETRIEVE NETWORK CAPABILITIES USING ANQP EXCHANGE
710
FULL MATCH(ES) BETWEEN STORED WIRELESS NETWORK CAPABILITIES PROFILES AND RETRIEVED WIRELESS NETWORK CAPABILITIES?
712
NO
YES
A
SELECT NETWORK THAT MATCHES PROFILE WITH HIGHEST PRIORITY RELATIVE TO OTHER MATCHING PROFILES
714
B

FIG. 7A

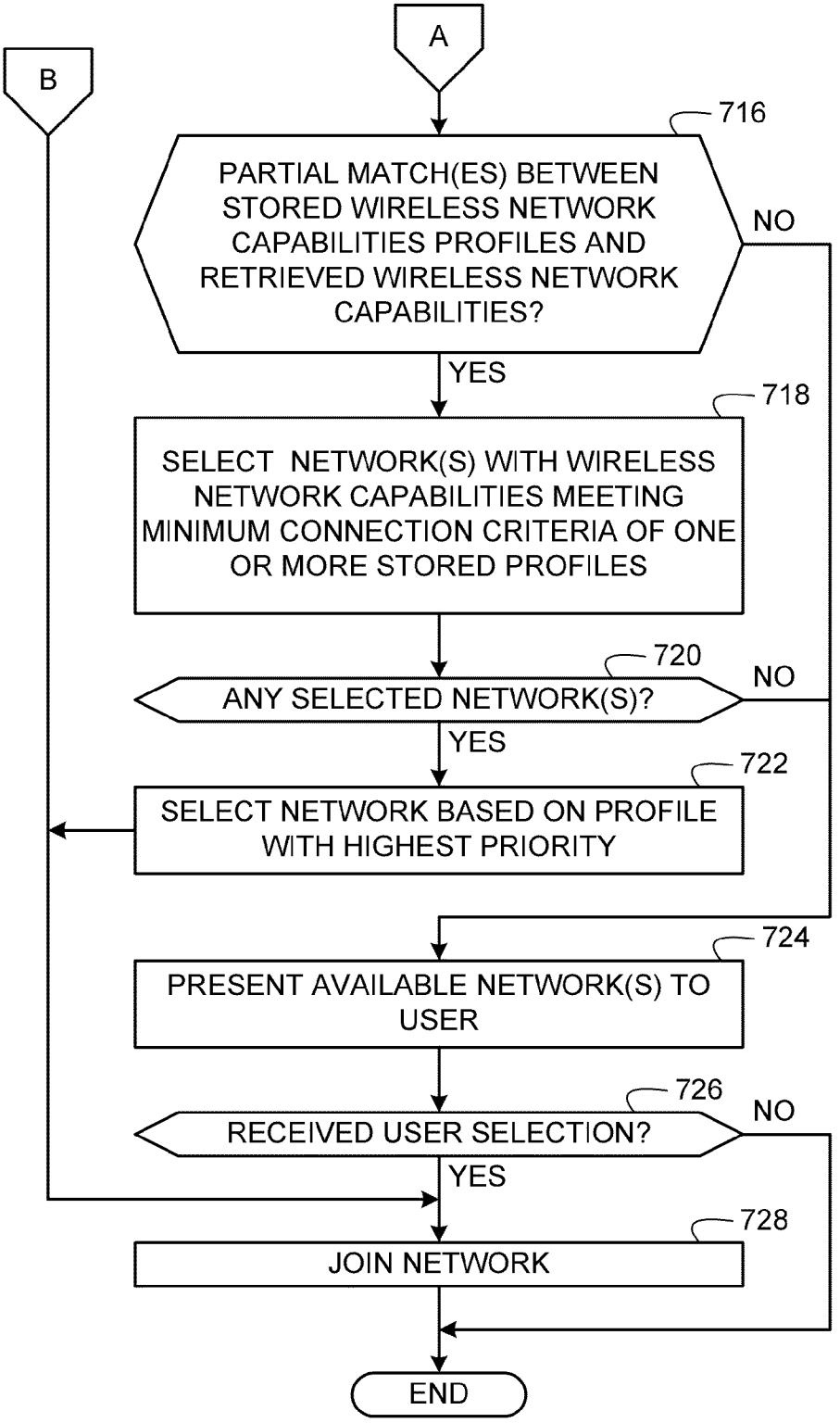

A
B
716
PARTIAL MATCH(ES) BETWEEN STORED WIRELESS NETWORK CAPABILITIES PROFILES AND RETRIEVED WIRELESS NETWORK CAPABILITIES?
NO
YES
718
SELECT NETWORK(S) WITH WIRELESS NETWORK CAPABILITIES MEETING MINIMUM CONNECTION CRITERIA OF ONE OR MORE STORED PROFILES
720
ANY SELECTED NETWORK(S)?
NO
YES
722
SELECT NETWORK BASED ON PROFILE WITH HIGHEST PRIORITY
724
PRESENT AVAILABLE NETWORK(S) TO USER
726
RECEIVED USER SELECTION?
NO
YES
728
JOIN NETWORK
END

FIG. 7B

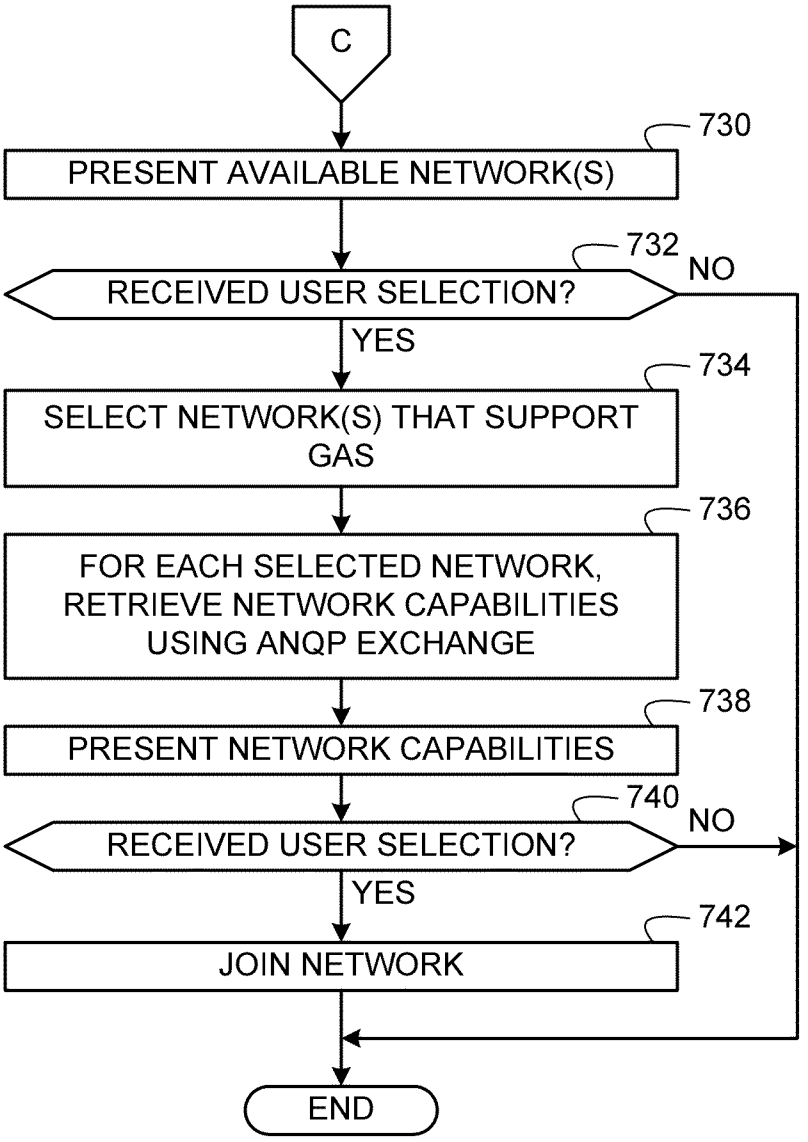

C
730
PRESENT AVAILABLE NETWORK(S)
732
RECEIVED USER SELECTION?
NO
YES
734
SELECT NETWORK(S) THAT SUPPORT GAS
736
FOR EACH SELECTED NETWORK, RETRIEVE NETWORK CAPABILITIES USING ANQP EXCHANGE
738
PRESENT NETWORK CAPABILITIES
740
RECEIVED USER SELECTION?
NO
YES
742
JOIN NETWORK
END

FIG. 7C

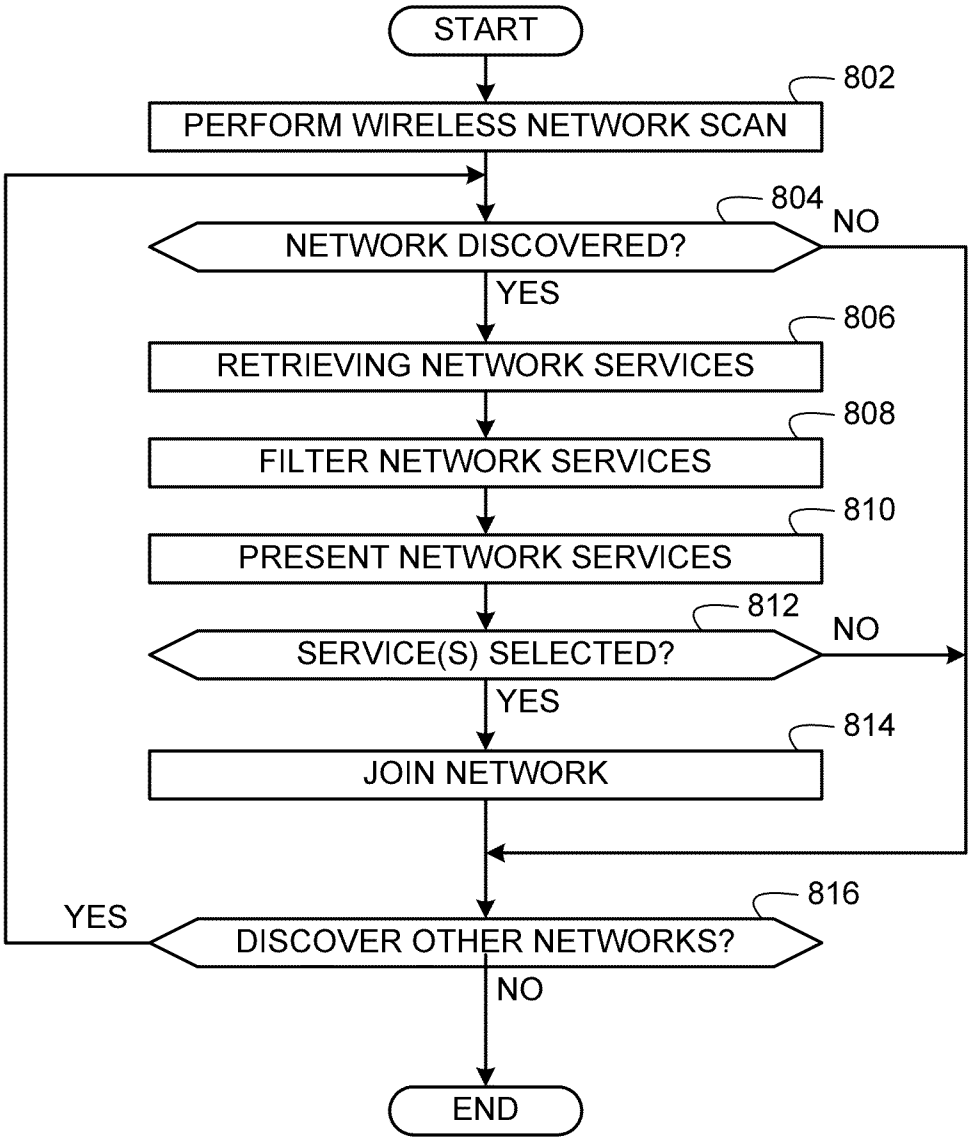

START
802
PERFORM WIRELESS NETWORK SCAN
804
NETWORK DISCOVERED?
NO
YES
806
RETRIEVING NETWORK SERVICES
808
FILTER NETWORK SERVICES
810
PRESENT NETWORK SERVICES
812
SERVICE(S) SELECTED?
NO
YES
814
JOIN NETWORK
816
YES
DISCOVER OTHER NETWORKS?
NO
END

FIG. 8

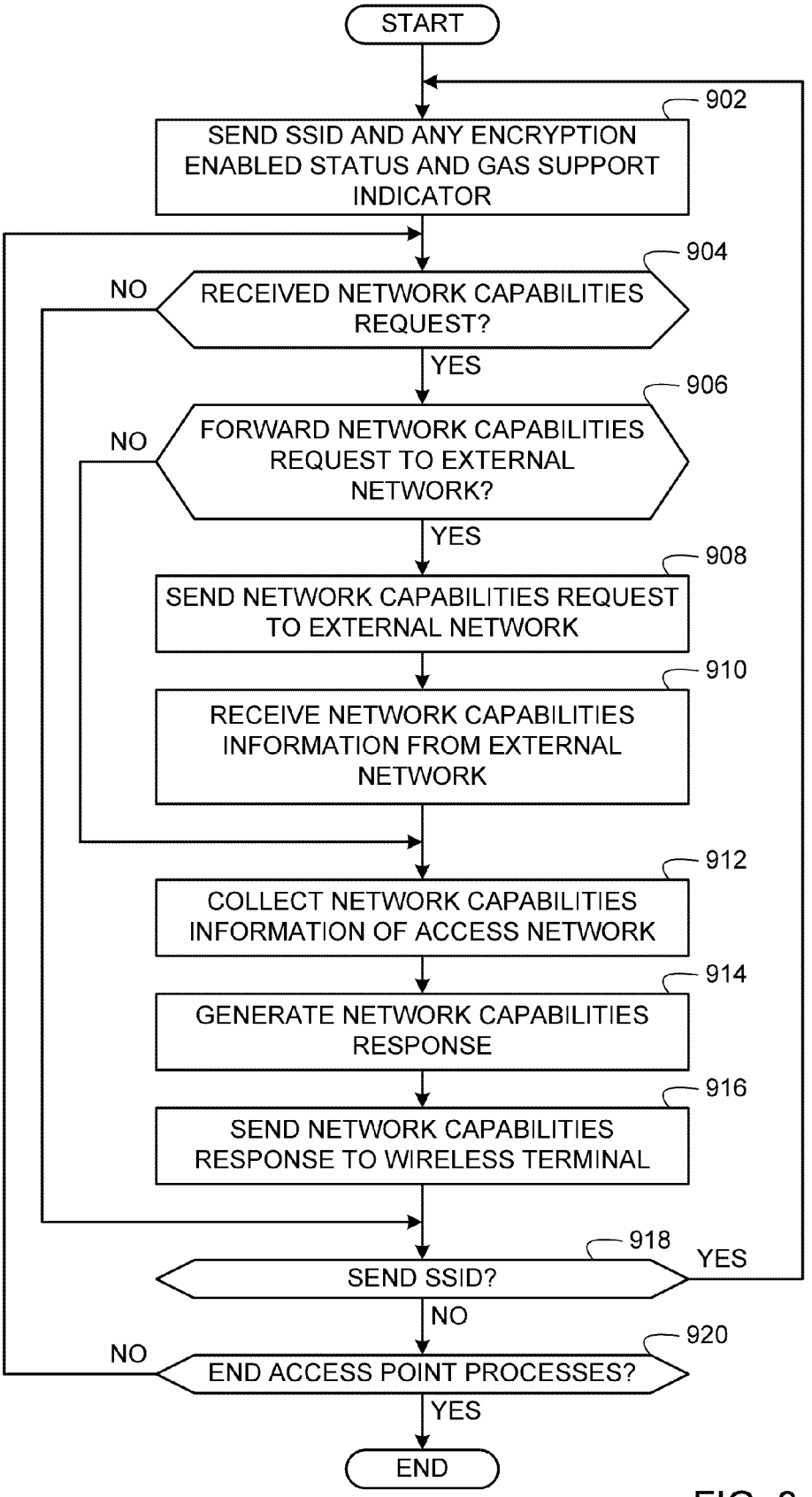

START
902
SEND SSID AND ANY ENCRYPTION ENABLED STATUS AND GAS SUPPORT INDICATOR
904
NO
RECEIVED NETWORK CAPABILITIES REQUEST?
YES
906
NO
FORWARD NETWORK CAPABILITIES REQUEST TO EXTERNAL NETWORK?
YES
908
SEND NETWORK CAPABILITIES REQUEST TO EXTERNAL NETWORK
910
RECEIVE NETWORK CAPABILITIES INFORMATION FROM EXTERNAL NETWORK
912
COLLECT NETWORK CAPABILITIES INFORMATION OF ACCESS NETWORK
914
GENERATE NETWORK CAPABILITIES RESPONSE
916
SEND NETWORK CAPABILITIES RESPONSE TO WIRELESS TERMINAL
918
YES
SEND SSID?
NO
920
NO
END ACCESS POINT PROCESSES?
YES
END

FIG. 9

METHODS AND APPARATUS TO DISCOVER NETWORK CAPABILITIES AVAILABLE VIA WIRELESS NETWORKS

RELATED APPLICATIONS

This patent arises from a continuation of U.S. patent application Ser. No. 12/893,835, filed on Sep. 29, 2010, which is hereby incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure relates generally to network communications and, more particularly, to methods and apparatus to discover network capabilities available via wireless networks.

BACKGROUND

Wireless network deployments, such as wireless local area networks (WLANs), allow wireless terminals to access network and Internet services when within proximity of wireless communication signals of those wireless networks. Different WLANs provide different network capabilities for wireless clients. Such network capabilities may include access to particular subscription service provider (SSP) networks, roaming agreements to allow connections from wireless clients associated with different SSPs, authentication capabilities to enable secure communications, support for emergency services, support for particular types of multi-media access (e.g., audio and/or video streaming, downloading, etc.), and/or support for other types of network services. If a wireless client joins a WLAN that does not provide a particular network capability, the wireless client cannot use such capability while associated with that WLAN.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts an example communication network in which a wireless terminal may communicate with a plurality of wireless local area networks.

FIG. **2** depicts a portion of the example communication network of FIG. **1** in which the wireless terminal may discover example network capabilities that may be accessed via one of the wireless local area networks of FIG. **1**.

FIG. **3** depicts example data structures cached and/or stored in a wireless terminal to facilitate selecting wireless networks to join based on received network capabilities of those networks and network capabilities profiles associated with the wireless terminal.

FIG. **4** depicts another example network capabilities profile data structure having network capabilities profiles defining different sets of network capabilities.

FIG. **5** depicts an example wireless terminal that may be used to implement the example methods and apparatus described herein.

FIG. **6** depicts an example wireless access point that may be used to implement the example methods and apparatus described herein.

FIGS. **7A-7C** depict a flow diagram representative of an example process that may be implemented by a wireless terminal to discover network capabilities available via one or more wireless local area networks.

FIG. **8** depicts a flow diagram representative of another example process that may be implemented by the wireless terminal of FIGS. **1-5** to discover network capabilities available via one or more WLANs.

FIG. **9** depicts a flow diagram representative of an example process that may be implemented by a wireless local area network access point to send network capabilities information to a wireless terminal.

DETAILED DESCRIPTION

Although the following discloses example methods and apparatus including, among other components, software executed on hardware, it should be noted that such methods and apparatus are merely illustrative and should not be considered as limiting. For example, it is contemplated that any or all of these hardware and software components could be embodied exclusively in hardware, exclusively in software, exclusively in firmware, or in any combination of hardware, software, and/or firmware. Accordingly, while the following describes example methods and apparatus, persons having ordinary skill in the art will readily appreciate that the examples provided are not the only way to implement such methods and apparatus.

The example methods and apparatus described herein can be used by wireless terminals to discover network capabilities that are available via wireless networks. Network capabilities are also referred to herein as network services supported by wireless networks. The example methods and apparatus described herein can be used in connection with mobile communication devices, mobile computing devices, or any other device capable of communicating wirelessly with a wireless network. Such devices, also referred to as terminals, wireless terminals, or user equipment (UE), may include mobile smart phones (e.g., a BlackBerry® smart phone), wireless personal digital assistants (PDA), laptop/notebook/netbook computers with wireless adapters, etc. The example methods and apparatus are described herein in connection with the wireless local area network (WLAN) communication standard known as IEEE® (Institute for Electrical and Electronics Engineers) 802.11, which, among other things, defines interworking with external networks. However, the example methods and apparatus may additionally or alternatively be implemented in connection with other wireless communication standards including other WLAN standards (e.g., any IEEE® 802.1x standard), personal area network (PAN) standards, wide area network (WAN) standards, or cellular communication standards.

Although the example methods and apparatus described herein may be implemented in any environment providing WLAN access for network connectivity, the example methods and apparatus can be advantageously implemented in WLAN access locations or environments in which it is expected that one or more users carrying respective wireless terminals will frequently connect to (or join) and disconnect from a WLAN as they enter and exit the WLAN access locations or environments. WLAN locations or environments are sometimes known as "hotspots" in reference to a location or environment that is within communication reach of WLAN signals. Such example WLAN locations or environments include coffee shops, retail stores, educational facilities, office environments, airports, public transportation stations and vehicles, hotels, etc. Such WLANs are often implemented as access networks that provide access to the Internet and may be associated with, or support access to, external networks (or WLAN-supported networks) owned and/or operated by subscription-based service providers. For example, an external network can be owned and/or operated by an Internet-access service provider or a telecommunications carrier/service provider that provides subscription-based Internet access for a fee (e.g., a monthly fee). In this

manner, a subscriber/user subscribed to such a service can use wireless network access and/or Internet-access services based on such a subscription when the subscriber is in communication proximity of the WLAN with an appropriate wireless terminal. In some instances, different WLANs may provide access to different types of network capabilities. For example, some WLANs may provide access to particular subscription service provider (SSP) networks, while others do not. In addition, some WLANs may support roaming agreements to allow connections from wireless terminals associated with different SSPs. Also, some WLANs may provide connection authentication capabilities to enable secure communications, may support particular emergency services, and/or may support particular types of multi-media access (e.g., audio and/or video streaming). WLANs may additionally or alternatively support other types of network access capabilities.

Known techniques for discovering network capabilities or network services available via WLANs can be time consuming and can adversely affect power consumption (and, thus, battery charge) of mobile devices. In addition, the user experience of known techniques or standards for associating a wireless terminal with a WLAN hotspot can be frustrating when network capabilities required by a wireless terminal and/or desired by a user of the wireless terminal are lacking via the WLAN hotspot. For example, known techniques for associating a wireless terminal with a WLAN involve the wireless terminal passively or actively scanning to discover one or more WLANs. The wireless terminal then selects a WLAN to join (e.g., based on advertised WLAN network properties such as a service set identifier (SSID), an encryption mode (e.g., wireless encryption protocol (WEP), Wi-Fi protected access (WPA), etc.), received signal strength indication (RSSI) and joins the selected WLAN. After joining the WLAN, known techniques may then be used to discover network capabilities available via the WLAN. However, if network capabilities required by the wireless terminal and/or desired by a user of the wireless terminal are not available, the WLAN association would be undesirable, yet the processing power and time for associating with the WLAN would already have been expended.

Unlike known techniques for discovering network capabilities, the example methods and apparatus described herein may be used to perform queries during a network discovery process to discover network capabilities available via WLANs. In this manner, a wireless terminal may obtain information on network capabilities made available by WLANs to determine, based on the network capabilities information, whether to continue with a connection process to join the wireless terminal with a WLAN. In accordance with the example techniques described herein, wireless terminals may request network capabilities information from WLANs using an Access Network Query Protocol (ANQP). The ANQP supports information retrieval from an Advertisement Server that supports a Generic Advertisement Service (GAS). ANQP and GAS are defined in IEEE® 802.11u. Additionally or alternatively, other query protocols (e.g., Registered Location Query Protocol (RLQP) as defined in IEEE® 802.11af, Hotspot Query Protocol (HSQP), and Online Signup Advertisement Protocol (OSAP) as defined in the Wi-Fi Alliance) may also be used in a similar manner to ANQP. An example ANQP exchange involves a requesting station (STA) (e.g., a wireless terminal) querying another STA (e.g., a WLAN access point (AP)) for information such as network capabilities information. The queried or receiving STA can respond to the received query with the requested information. The queried or receiving STA can generate the response information with or without proxying the query to a server in an external network (e.g., an SSP network). For example, an external network connected to a queried WLAN may have particular network capabilities accessible via the WLAN and of which a querying wireless terminal should be made aware. Although example methods and apparatus are described herein in connection with ANQP and GAS, other query protocols and information exchange services may alternatively or additionally be used.

To facilitate selections of WLANs as candidates for association, a wireless terminal may locally store one or more network capabilities profiles, each of which may define a different set of network capabilities. In this manner, when the wireless terminal receives information indicative of network capabilities that are available via a WLAN, the wireless terminal may compare the network capabilities to its stored network capabilities profiles. Network capabilities profiles specifying network capabilities or minimum network capabilities requirements that match the network capabilities of the WLAN can be identified by the wireless terminal as indicating that the WLAN is a suitable candidate to join. If the wireless terminal finds that the WLAN is suitable to join, the wireless terminal may proceed with joining the WLAN.

A wireless terminal may join a WLAN using a manual mode (e.g., in response to a user selection of one of a plurality of available WLANs) or using an automatic mode. In the illustrated examples described herein, an automatic mode involves a wireless terminal selecting a WLAN candidate based on a filtering scheme. For example, network capabilities profiles stored in a wireless terminal may be assigned ranking levels (e.g., by a user, the wireless terminal, an SSP, etc.) such that the wireless terminal can select a highest ranking one of the network capabilities profiles that meets at least a minimum quantity of network capability matches. In some example implementations, the automatic mode of joining a WLAN may be advantageously used in connection with wireless terminals that do not provide displays or user-input interfaces to allow users to enter WLAN selections. For example, an 802.11-based, wireless Ethernet portable music player may provide a user interface to enable selecting streaming music stations, but the user interface may not be sufficiently sophisticated to enable other types of user-entered information (e.g., WLAN selection). However, the methods and apparatus described herein can enable such a portable music player to join a WLAN hotspot when the portable music player has stored therein a network capabilities profile having a minimum quantity of matches with network capabilities available via the WLAN hotspot.

In some example implementations, the network capability discovery techniques described herein may be used for network discovery instead of SSID-based network discovery. For example, rather than using SSIDs as the primary mode for network discovery, a wireless terminal may use network capabilities information received from APs and its stored WLAN profiles to determine when it is in the vicinity of WLANs suitable for association.

Turning now to FIG. **1**, an example communication network **100** in which the example methods and apparatus described herein may be implemented is shown. As shown in FIG. **1**, the example communication network **100** includes a plurality of WLAN access locations **102***a-c* having respective access points **104***a-c* that provide access to respective access networks **106***a-c*. In the illustrated example, the access network A **106***a* provides access to an external network A **108***a* and the access network B **106***b* provides access to an external network B **108***b*. In the illustrated example, each of the external networks A **108***a* and B **108***b* may be a subscription

service provider (SSP) network owned and/or operated by data subscription service providers, Internet subscription service providers, media (e.g., audio/video) subscription service providers, wireless communications subscription service providers, or any combination thereof. In the illustrated example, the external networks A **108***a* and B **108***b* are connected to the Internet **112** and may, for example, provide subscription-based Internet access to wireless terminals. In some example implementations, roaming agreements between different SSPs may enable the external networks A **108***a* and B **108***b* to support roaming connections for wireless terminals associated with other SSPs.

Unlike the access networks A **106***a* and B **106***b* that do not connect directly to the Internet **112**, the access network C **110** is connected directly to the Internet. Thus, the access network C **106***c* may be a public network, while the access networks A **106***a* and B **106***b* may be private networks.

Although not shown, each of the APs **104***a-c* and a wireless terminal **114**, that communicates with the APs **104***a-c*, is provided with a station (STA), which is the interface or component, such as a network adapter or network interface card (NIC), that connects to a wireless medium.

Each of the access networks **106***a-c* and the external networks **108***a-b* may be associated with and/or provide access to different network capabilities. The network capabilities may include roaming relationships, network services, multimedia access services, supported authentication and/or security methods, emergency services, etc. The network capabilities may be selected by respective owners or operators of the networks **106***a-c*, **108***a*, and **108***b* based on different factors such as, for example, subscription usage plans, desired security levels, business objectives, roaming agreements, supported emergency services, supported multi-media access, available Internet access, etc. For instance, if an SSP associated with the external network A **108***a* only allows access by subscribers of its services, the external network A **108***a* may advertise that it does not support roaming connections.

The example methods and apparatus described herein may also enable the wireless terminal **114** to join different APs (e.g., the APs **104***a-c*) based on different network capabilities profiles stored in the wireless terminal **114**. That is, when the wireless terminal **114** is moved to a different one of the WLAN access locations **102***a-c*, the wireless terminal **114** can dynamically discover network capabilities available at the WLAN access locations **102***a-c* and join any suitable one of the APs **104***a-c* even when the wireless terminal **114** has not previously encountered the APs **104***a-c* or the network capabilities available via the APs **104***a-c* have changed since a previous connection between the wireless terminal **114** and the APs **104***a-c*.

As shown generally in connection with the WLAN access location **102***a*, the wireless terminal **114** can send a network capabilities request (NETCAP REQUEST) message **116** to the AP **104***a* and receive a network capabilities response (NETCAP RESPONSE) message **118** including network information **120** indicating one or more network capabilities (of the access network A **106***a* and/or the external network A **108***a*) available via the access point **104***a*. The wireless terminal **114** and the AP **104***a* may exchange the NETCAP REQUEST **116** and NETCAP RESPONSE **118** using the ANQP protocol after the wireless terminal **114** receives an SSID of the AP **104***a* or without the wireless terminal **114** needing to have received the SSID. In addition, the NETCAP REQUEST **116** and the NETCAP RESPONSE **118** may be exchanged at a media access control (MAC) sub-layer of the well-known Open Systems Interconnection (OSI) Reference Model without needing to use operations at or above an internet protocol (IP) layer (i.e., a network layer) nor needing to otherwise provide access to the IP layer while discovering network capabilities available via the AP **104***a*.

Discovering network capabilities using messages exchanged at or above the network layer requires relatively more processing power of a wireless terminal than implementing processes at the MAC sub-layer. Mobile wireless terminals (e.g., the wireless terminal **114** of FIG. **1**) such as mobile smart phones, PDA's, etc. often have relatively limited processor cycles and less available electrical power than fixed-location computing devices powered using alternating current (AC) electricity sources. The example methods and apparatus described herein can be advantageously used to configure, design, or otherwise engineer mobile wireless terminals to operate more efficiently (i.e., do more with fewer processor cycles) and, thus, reduce battery power use. That is, the example methods and apparatus described herein can be advantageously used to promote mobile wireless terminal designs that consume relatively less power and operate relatively more efficiently. For example, low-level resource operations at the MAC sub-layer require relatively fewer system resources than user-interface-intensive and operating system (OS)-intensive operations (e.g., web-browser operations) at an application layer of the OSI Reference Model.

Another example advantage of discovering network capabilities available via APs using the MAC sub-layer is that a network capability discovery process can, without user involvement or with minimal user involvement, determine whether an AP is a suitable candidate for association based on minimal requirements of network capabilities profiles stored in the wireless terminal **114**. For example, if the AP **104***a* advertises that it does not support roaming and the wireless terminal **114** would need to join the AP **104** under a roaming policy, the wireless terminal **114** can be configured to ignore the presence of the AP **104***a* because the wireless terminal **114** would be denied network access via the AP **104***a*. In some example implementations, the wireless terminal **114** can be configured to not inform its user of the presence of the AP **104***a* during a WLAN discovery process when it would not be possible for the wireless terminal **114** to connect to the AP **104***a* without minimum network capabilities required by the network capabilities profiles of the wireless terminal **114**. Such example implementations substantially reduce or eliminate user frustration because the user would not need to engage in any attempts to join a particular AP when the AP does not meet the minimum network capability requirements of the wireless terminal **114**.

Although an SSID is used in connection with the some example implementations described herein, an AP may alternatively be configured to broadcast a Homogeneous Extended Service Set Identifier (HESSID). An HESSID includes an SSID associated with a particular AP and a network identification corresponding to a supported external network (e.g., a SSP network). For instance, if the AP **104***a* of FIG. **1** were configured to broadcast an HESSID, it would include the SSID of the AP **104***a* and the network identification corresponding to the external network A **108***a*.

Other example advantages of the example techniques described herein result from the wireless terminal **114** discovering network capabilities each time it encounters an AP. In this manner, the wireless terminal **114** need not be preprogrammed to know network capabilities available via different APs. In addition, network capabilities of different networks (e.g., the access networks **106***a-c*, **108***a*, and **108***b*) may be changed at any time because wireless terminals can discover the changed network capabilities anew each time the wireless terminals discover (or re-discover) the networks.

FIG. **2** depicts a portion of the example communication network **100** of FIG. **1** in which the wireless terminal **104** may discover example network capabilities that may be accessed via the AP **104***a*. Although not shown, the wireless terminal **104** may discover network capabilities available via the APs **104***b* and **104***c* or any other AP using similar or identical techniques as described in connection with FIG. **2**. In the illustrated example of FIG. **2**, the external network A **108***a* includes an external network capabilities data store **202** to store network capabilities **206***a-f* of the external network A **108***a*. In the illustrated example, the network capabilities **206***a-f* include one or more roaming policies **206***a*, network service(s) capabilities **206***b*, emergency services support **206***c*, subscription service provider (SSP) identifier(s) **206***d*, multimedia access types **206***e*, and authentication methods **206***f*.

In the illustrated example, the one or more roaming policies **206***a* may be based on agreements between the SSP(s) of the external network A **108***a* and one or more other SSP(s) to allow wireless terminals to join the access network **106***a* under a roaming mode and, in turn, the external network A **108***a*. The network service(s) **206***b* may identify one or more network services (e.g., Internet connectivity, media streaming, secure protocols, no payment required, etc.) supported for communication with or via the external network A **108***a*. The emergency service(s) **206***c* may indicate the types of emergency services that are supported or provided by the external network A **108***a*. The SSP ID(s) **206***d* identify one or more SSPs that support or provide service via by the external network A **108***a*. A wireless terminal associated with a service subscription of an SSP that supports or provides service via the external network A **108***a* may join the access network A **106***a* to access the external network A **108***a* without requiring a roaming agreement. The multimedia access types **206***e* indicate the types of multimedia (e.g., video, audio, IP television (IPTV), etc.) that may be accessed via the external network A **108***a*. The authentication methods **206***f* may include identifiers of one or more authentication methods supported by the external network A **108***a*. An example authentication method is an Extensible Authentication Protocol (EAP) method. Known EAP methods include EAP-WISP (wireless internet service provider), EAP-MD5, EAP-OTP, EAP-GTC, EAP-TLS, EAP-IKEv2, EAP-SIM, EAP-AKA, EAP-FAST, EAP-TTLS, and PEAP. Each EAP method can be identified using a corresponding integer-format value assigned by an industry-standard resource coordination body such as the Internet Assigned Numbers Authority (IANA) (http://www.iana.org). Other EAP methods can also include vendor-specific methods.

In the illustrated example, the access network A **106***a* is provided with an access network capabilities data store **208** to store network capabilities of the access network A **106***a*. Although not shown, the access capabilities stored in the access network capabilities data store **208** may be of the same type as the network capabilities **206***a-f* stored in the external network capabilities data store **202** or may be of any other suitable types of network capabilities.

In the illustrated example, the network capabilities **206***a-f* and network capabilities stored in the access network capabilities data store **208** may be organized using an extensible markup language (XML) structure. In this manner, the AP **104***a* and the wireless terminal **114** can exchange registration requirements and registration information using the XML format. Alternatively, the network capabilities **206***a-f* and network capabilities stored in the access network capabilities data store **208** can be organized as sets of enumerated types, and the AP **104***a* and the wireless terminal **114** can exchange registration requirements and registration information using a type-length-value (TLV) structure format. For example, the AP **104***a* can encapsulate ones of the network capabilities in TLV type structures for communication to the wireless terminal **114** (e.g., via the NETCAP RESPONSE **118**).

In the illustrated example of FIG. **2**, the wireless terminal **114** stores network capabilities profiles **210**, each of which may define a different set of network capabilities. The wireless terminal **114** may use the network capabilities profiles **210** to identify suitable WLAN candidates that the wireless terminal **114** may join. In some example implementations, each of the network capabilities profiles **210** may be assigned a respective ranking so that the wireless terminal **114** may perform a ranking process when a WLAN (e.g., the access network A **106***a*) has network capabilities that meet a minimum capabilities requirement of more than one of the network capabilities profiles **210**. Example implementations of the network capabilities profiles **210** are described below in connection with FIGS. **3** and **4**.

In the illustrated example of FIG. **2**, the wireless terminal **114** uses the network capabilities profiles **210** during a network discovery process to determine whether any APs within a wireless communication vicinity of the wireless terminal **114** are suitable candidates for association. As shown in FIG. **2**, during a network discovery process, the wireless terminal **114** may receive an SSID **212** and an encryption mode status **214** from the AP **104***a*. In the illustrated example, the encryption mode status **214** indicates whether an encryption mode (e.g., wireless encryption protocol (WEP), Wi-Fi protected access (WPA), etc.) is enabled on the AP **104***a*. Although not shown, the wireless terminal **114** may also simultaneously receive other SSIDs and encryption mode statuses from other nearby APs. In some example implementations, the AP **104***a* may also communicate a GAS support indicator **216** (typically implemented as an Interworking element in the beacon or probe response of an IEEE® 802.11 WLAN) to the wireless terminal **114**, as shown in FIG. **2**. The GAS support indicator **216** indicates that the access network A **106***a* supports GAS. The wireless terminal **114** may use this information to communicate with the AP **104***a* using protocols transported over GAS (e.g., ANQP messages). If a WLAN does not support GAS, it will not transmit the GAS support indicator **216**.

In some example implementations, after receiving the SSID **212** and the encryption mode status **214** (and the GAS support indicator **216**, if applicable), the wireless terminal **114** sends the NETCAP REQUEST **116** to the AP **104***a* to request network capabilities that are available via the access network A **106***a*. In the illustrated example, the network capabilities may be provided by the access network A **106***a* and/or the external network A **108***a*. If the external network A **108***a* provides some network capabilities, the access network A **106***a* may relay, forward, or otherwise send an external network capabilities request (EXT-NETCAP REQUEST) **218** to the external network A **108***a* in response to receiving the NETCAP REQUEST **116** from the wireless terminal **114**. In response to the EXT-NETCAP REQUEST **218**, the external network A **108***a* sends its network capabilities (e.g., one or more of the network capabilities **206***a-f*) to the access network A **106***a* via an EXT-NETCAP RESPONSE **220**.

The access network A **106***a* forms the NETCAP RESPONSE **118** to include the network capabilities of the external network A **108***a* and any network capabilities provided by the access network A **106***a*. The AP **104***a* then sends the NETCAP RESPONSE **118** to the wireless terminal **114** to inform the wireless terminal **114** of the network capabilities that are available via the access network A **106***a*. The wireless

terminal **114** may then compare the received network capabilities with network capabilities indicated in each of its network capabilities profiles **210** to determine whether minimum network capability requirements are met for any of the network capabilities profiles **210** to indicate that the access network A **106***a* is a suitable candidate for association.

Turning now to FIG. **3**, the wireless terminal **114** caches and/or stores an example network capabilities profile data structure **302** having network capabilities profiles (e.g., the network capabilities profiles **210** of FIG. **2**) specifying different sets of network capabilities. In the illustrated example, the wireless terminal **114** also caches discovered network capabilities **304** received from one or more wireless networks (e.g., wireless networks associated with the APs **104***a-c*) during a wireless network scan. In example implementations, the wireless terminal **114** uses the network capabilities profile data structure **302** and the discovered network capabilities **304** to select wireless networks to join based on network capabilities of discovered wireless networks (e.g., the discovered network capabilities **304**) and network capabilities (e.g., one or more network capabilities specified in the network capabilities profile data structure **302**) that are desired for use with the wireless terminal **114**. In some example implementations, the wireless terminal **114** may also use a cached or stored SSID priority list **306** indicating a priority order of one or more SSIDs to select a wireless network to join when two or more wireless networks advertise network capabilities equally desired for use with the wireless terminal **114** (e.g., based on the network capabilities specified in the network capabilities profile data structure **302**).

In the illustrated example of FIG. **3**, each network capabilities profile in the network capabilities profile data structure **302** is assigned a unique profile ID **308** and includes rankings **310**, minimum capabilities **312**, and additional capabilities **314**. Turning to the discovered network capabilities **304**, during wireless network scans performed by the wireless terminal **114** to discover available WLANs (e.g., the access networks **106***a-c* of FIG. **1**) in its vicinity, the wireless terminal **114** caches discovered SSIDs **316**. For each discovered SSID **316**, the wireless terminal **114** sends an ANQP query to each discovered WLAN requesting the network capabilities of those networks. The wireless terminal **114** then caches the received network capabilities **318** as shown in FIG. **3**. In the illustrated example of FIG. **3**, the cached network capabilities **318** are shown as <X>, <Y>, and <M> for each respective WLAN. Each notation <X>, <Y>, and <M> represents a listing of one or more network capabilities or services available via the respective WLAN.

Referring back to the network capabilities profile data structure **302**, the minimum capabilities **312** are denoted as <X>, <Y>, <M>, <N>, and <O>, each of which indicates one or more network capabilities (for each profile) that must be available via a WLAN (e.g., the access network **106***a* of FIGS. **1** and **2**) to consider that WLAN a suitable candidate for the wireless terminal **114** to join. For example, if discovered network capabilities (e.g., network capabilities <Y> cached in the discovered network capabilities **304**) available via the access network A **106***a* do not meet the minimum network capabilities of profile ID 0001, then the access network A **106***a* would not be regarded as a suitable candidate based on the profile ID 0001. However, if the same discovered network capabilities (e.g., network capabilities <Y>) of the access network A **106***a* do meet the minimum network capabilities of profile ID 0002, then the access network A **106***a* would be regarded as a suitable candidate based on the profile ID 0002. Thus, network capabilities of a WLAN need to at least meet the minimum network capabilities of one network capabilities profile for that WLAN to be regarded as a suitable candidate for joining by the wireless terminal **114**.

In the illustrated example of FIG. **3**, the additional capabilities **314** specifies network capabilities for each network capabilities profile that are not necessarily required for a WLAN to be considered a suitable association candidate. However, the network capabilities specified in the additional capabilities **314** could be additional desired network capabilities. In some example implementations, the additional capabilities **314** may be used to select a WLAN that the wireless terminal **114** should join when multiple WLANs have been identified as suitable association candidates. For example, the wireless terminal **114** may discover the access network A **106***a* and the access network B **106***b* of FIG. **1** during the same network scan, and the access network A **106***a* may meet the minimum network capabilities requirements of profile ID 0001, while the access network B **106***b* may meet the minimum network capabilities requirements of profile ID 0002. In such an example, the wireless terminal **114** or a user of the wireless terminal **114** may select to connect to the access network A **106***a* if the network capabilities accessible via the access network A **106***a* match more of the network capabilities specified in the additional capabilities **314** for the profile ID 0001 than the quantity or percentage of matches between the network capabilities accessible via the access network B **106***b* and the additional capabilities **314** for the profile ID 0002.

In some example implementations, WLANs may be selected for association based on rankings of network capabilities profiles. In the illustrated example, the network capabilities profiles are assigned ranking values **310** to indicate their order of preference for use when selecting a WLAN from more than one suitable association candidate. The ranking values **310** may be specified by the wireless terminal **114** or by a SSP based on rules or criteria related to preferable wireless connections. Alternatively, the ranking values **310** may be specified by a user of the wireless terminal **114** based on wireless connection preferences of the user. During a network discovery process, when the wireless terminal **114** finds that more than one WLAN (e.g., the access networks A **106***a*, B **106***b*, and C **106***c*) is a suitable association candidate, the wireless terminal **114** may rank each of the WLANs based on the ranking values **310** assigned to corresponding ones of the network capabilities profiles that match those WLANs. For example, if network capabilities available via the access network A **106***a* align with the minimum capabilities **312** of the profile ID 0003 and the network capabilities of the access network B **106***b* align with the minimum capabilities **312** of the profile ID 0005, both of the access networks A **106***a* and B **106***b* are suitable association candidates, but the wireless terminal **114** selects the access network A **106***a* because the network capabilities profile (profile ID 0003) satisfied by the network capabilities of the access network A **106***a* has the higher capability ranking.

In the illustrated example, the wireless terminal **114** may use priorities of SSIDs listed in the SSID priorities table **306** to break a 'tie' when more than one discovered WLAN achieves the same one of the rankings **310**. That is, if two WLANs with different SSIDs meet the minimum capabilities **312** of the same network capabilities profile, the wireless terminal **114** may select the WLAN having the highest priority SSID according the SSID priorities list **306**.

Turning now to FIG. **4**, another example network capabilities profile data structure **400** is shown with example minimum network capabilities or services shown for each network capabilities profile. In addition, FIG. **4** shows that network capabilities profiles may be defined independent of network

SSIDs. That is, unlike traditional network discovery techniques that rely on the SSID of a network to determine whether to join that network, the wireless terminal **114** may instead rely on the network capabilities of a WLAN exclusive of the SSID of the WLAN to determine whether the WLAN is a suitable candidate to join.

The network capabilities profile data structure **400** may be cached or stored in the wireless terminal **114**. In the illustrated example of FIG. **4**, the network capabilities profile data structure **400** stores a plurality of network capabilities profiles (e.g., the network capabilities profiles **210** of FIG. **2**) specifying different sets of network capabilities. Each network capabilities profile is provided with a profile ID **402** and minimum capabilities **404** specifying the network capabilities required to recognize that a WLAN (e.g., any of the access networks **106***a-c* of FIG. **1**) is available for associating with by the wireless terminal **114**. For example, the network capabilities profile having profile ID 0001 requires only that a WLAN have a network access identifier (NAI) of 'MYPROVIDER.COM' to be considered a suitable association candidate for the wireless terminal **114**. In such an example, 'MYPROVIDER.COM' may be the NAI of an SSP that provides a subscription service for the wireless terminal **114**.

In the illustrated example, each of the network capabilities profiles is associated with a wildcard (*) as an SSID **406**. The SSID wildcard (*) indicates that the SSID of a WLAN can be anything. That is, regardless of a particular SSID, the wireless terminal **114** can detect a WLAN as being available for association if the network capabilities available via the WLAN satisfy the network capabilities specified in the minimum capabilities **404** for any of the network capabilities profiles of the network capabilities profile data structure **400**.

In some example implementations, the network capabilities profile data structure **400** may also be provided with ranking values such as the ranking values **310** of FIG. **3** and additional capabilities such as the additional capabilities **314** of FIG. **3**.

Although not shown, the minimum capabilities **404** of FIG. **4** (and/or the minimum capabilities **312** of FIG. **3**) may specify credentials for particular network services. For example, a roaming credential may be specified in a network capabilities profile indicating that, for that particular profile, a roaming network service of a wireless network must support roaming access to roam onto a network of an SSP indicated by the roaming credential. In such example implementations, if a network capabilities profile specifies a roaming credential as a minimum capability, the wireless terminal **114** must confirm that a WLAN supports roaming access to a SSP specified by the roaming credential of that profile. Otherwise, if roaming access corresponding to that roaming credential is not supported by a particular WLAN, the wireless terminal **114** will not consider that WLAN as a suitable candidate for joining.

Referring now to FIG. **5**, an illustrated example of the wireless terminal **114** of FIGS. **1-4** is shown in block diagram form. In the illustrated example, the wireless terminal **114** includes a processor **502** that may be used to control the overall operation of the wireless terminal **114**. The processor **502** may be implemented using a controller, a general purpose processor, a digital signal processor, dedicated hardware, or any combination thereof.

The wireless terminal **114** also includes a terminal message generator **504** and a terminal data parser **506**. The terminal message generator **504** may be used to generate network capability discovery messages such as the NETCAP REQUEST **116** of FIGS. **1** and **2**. The terminal data parser **506** may be used to retrieve information from memory (e.g., a RAM **510**, a cache, etc.). For example, the terminal data parser **506** can retrieve SSIDs (e.g., the SSID **212** of FIG. **2**), encryption mode statuses (e.g., the encryption mode status **214** of FIG. **2**), GAS support indicators (e.g., the GAS support indicator **216** of FIG. **2**) and network capabilities that are cached in the wireless terminal **114** after receiving them from a WLAN (e.g., the access networks **106***a-c* of FIG. **1**).

Although the terminal message generator **504** and the terminal data parser **506** are shown as separate from and connected to the processor **502** in FIG. **5**, in some example implementations, the terminal message generator **504** and the terminal data parser **506** may be implemented in the processor **502** and/or in a wireless communication subsystem (e.g., a wireless communication subsystem **518**). The terminal message generator **504** and the terminal data parser **506** may be implemented using any desired combination of hardware, firmware, and/or software. For example, one or more integrated circuits, discrete semiconductor components, and/or passive electronic components may be used. Thus, for example, the terminal message generator **504** and the terminal data parser **506**, or parts thereof, could be implemented using one or more circuit(s), programmable processor(s), application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)), field programmable logic device(s) (FPLD(s)), etc. The terminal message generator **504** and the terminal data parser **506**, or parts thereof, may be implemented using instructions, code, and/or other software and/or firmware, etc. stored on a machine accessible medium and executable by, for example, a processor (e.g., the example processor **502**). When any of the appended claims are read to cover a purely software implementation, at least one of the terminal message generator **504** or the terminal data parser **506** is hereby expressly defined to include a tangible medium such as a solid state memory, a magnetic memory, a DVD, a CD, etc. As used herein, the term tangible computer readable medium is expressly defined to include any type of computer readable storage and to exclude propagating signals. Additionally or alternatively, at least one of the terminal message generator **504** or the terminal data parser **506** is hereby expressly defined to include a non-transitory computer readable medium such as a flash memory, a read-only memory (ROM), a random-access memory (RAM), a cache, or any other storage media in which information is stored for any duration (e.g., for extended time periods, permanently, brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable medium and to exclude propagating signals.

The example wireless terminal **114** shown in FIG. **5** also includes a FLASH memory **508**, a random access memory (RAM) **510**, and an expandable memory interface **512** communicatively coupled to the processor **502**. The FLASH memory **508** can be used to, for example, store computer readable instructions and/or data. In some example implementations, the FLASH memory **508** can be used to store one or more of the data structures discussed above in connection with FIGS. **3** and **4**. The RAM **510** can also be used to, for example, store data and/or instructions.

The wireless terminal **114** is provided with a security hardware interface **514** to receive a SIM card (or a USIM card or a NFC secure element) from a wireless service provider. A SIM card may be used as an authentication parameter to authenticate the wireless terminal **114** for establishing a connection with a WLAN-supported network. In some example implementations, a SIM card may also store registration information required to register with external networks. The

wireless terminal **114** is also provided with an external data I/O interface **516**. The external data I/O interface **516** may be used by a user to transfer information to the wireless terminal **114** through a wired medium.

The wireless terminal **114** is provided with a wireless communication subsystem **518** to enable wireless communications with APs (e.g., the APs **104***a-c* of FIG. **1**). Although not shown, the wireless terminal **114** may also have a long-range communication subsystem to receive messages from, and send messages to, a cellular wireless network. In the illustrated examples described herein, the wireless communication subsystem **518** can be configured in accordance with the IEEE® 802.11 standard. In other example implementations, the wireless communication subsystem **518** can be implemented using a BLUETOOTH® radio, a ZIGBEE® device, a wireless USB device, an ultra-wideband (UWB) radio, a Near Field Communications (NFC) device, or a Radio Frequency Identifier (RFID) device.

To enable a user to use and interact with or via the wireless terminal **114**, the wireless terminal **114** is provided with a speaker **520**, a microphone **522**, a display **524**, and a user input interface **526**. The display **524** can be an LCD display, an e-paper display, etc. The user input interface **526** could be an alphanumeric keyboard and/or telephone-type keypad, a multi-direction actuator or roller wheel with dynamic button pressing capability, a touch panel, etc. As discussed above, the example methods and apparatus described herein can also be advantageously used in connection with wireless terminals that do not have user interfaces and, thus, the speaker, **520**, the microphone **522**, the display **524**, the user input interface **526**, and/or any combination thereof may be optionally omitted. In the illustrated example, the wireless terminal **114** is a battery-powered device and is, thus, provided with a battery **528** and a battery interface **530**.

Turning now to FIG. **6**, the example AP **104***a* of FIGS. **1** and **2** is shown in block diagram form. The APs **104***b* and **104***c* of FIG. **1** may be implemented using a substantially similar or identical configuration. The example AP **104***a* includes a processor **602** to perform the overall operations of the AP **104***a*. In addition, the AP **104***a* includes an AP message generator **604** to generate TLV or XML-formatted messages or messages of any other type of format (e.g., the NETCAP RESPONSE **118** of FIG. **1**, the EXT-NETCAP REQUEST **218** of FIG. **2**, and/or messages to send the SSID **212**, the encryption mode status **214**, and the GAS support indicator **216** of FIG. **2**). The AP **104***a* also includes an AP data parser **606** to retrieve information from received messages sent by the wireless terminal **114** and/or the external network A **108***a* (FIGS. **1** and **2**). The AP message generator **604** is substantially similar to the terminal message generator **504** of FIG. **5**, and the AP data parser **606** is substantially similar to the terminal data parser **506** of FIG. **5**. Thus, the AP message generator **604** and the AP data parser **606** may be implemented in the processor **602** and/or a wireless communication subsystem (e.g., a wireless communication subsystem **612**) using any combination of hardware, firmware, and/or software including instructions stored on a tangible computer readable medium and/or a non-transitory computer readable medium.

The example AP **104***a* also includes a FLASH memory **608** and a RAM **610**, both of which are coupled to the processor **602**. The FLASH memory **608** may be configured to store network capabilities information (e.g., the access network capabilities data store **208** of FIG. **2**). The RAM **610** may be used to generate messages for communication to the wireless terminal **114** and/or to the external network A **108***a* and/or to store received messages communicated by the wireless terminal **114** and/or the external network A **108***a*.

To communicate with wireless terminals such as the wireless terminal **114**, the AP **104***a* is provided with a wireless communication subsystem **612**, which may be substantially similar or identical to the wireless communication subsystem **518** (FIG. **5**) of the wireless terminal **114**. To communicate with a WLAN-supported network or external network (e.g., the networks **106***a-c*, **108***a*, and **108***b* of FIG. **1**), the AP **104***a* is provided with a network uplink communication interface **614**.

FIGS. **7**A-**7**C depict a flow diagram representative of an example process that may be implemented by the wireless terminal **114** of FIGS. **1**-**5** to discover network capabilities available via one or more WLANs (e.g., the access networks **106***a-c* of FIGS. **1** and **2**). FIG. **8** depicts a flow diagram representative of another example process that may be implemented by the wireless terminal **114** of FIGS. **1**-**5** to discover network capabilities via one or more WLANs. FIG. **9** depicts a flow diagram representative of an example process that may be implemented by an AP (e.g., one or more of the APs **104***a-c* of FIGS. **1** and **2**) to send network capabilities information to the wireless terminal **114**. The example processes of FIGS. **7**A-**7**C, **8** and **9** may be performed using a processor, a controller and/or any other suitable processing device. For example, the example processes of FIGS. **7**A-**7**C, **8**, and **9** may be implemented using coded instructions (e.g., computer readable instructions) stored on a tangible computer readable medium such as a FLASH memory, a read-only memory (ROM), and/or a random-access memory (RAM). As used herein, the term tangible computer readable medium is expressly defined to include any type of computer readable storage and to exclude propagating signals. Additionally or alternatively, the example processes of FIGS. **7**A-**7**C, **8**, and **9** may be implemented using coded instructions (e.g., computer readable instructions) stored on a non-transitory computer readable medium such as a flash memory, a read-only memory (ROM), a random-access memory (RAM), a cache, or any other storage media in which information is stored for any duration (e.g., for extended time periods, permanently, brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable medium and to exclude propagating signals.

Alternatively, some or all of the example processes of FIGS. **7**A-**7**C, **8**, and **9** may be implemented using any combination(s) of application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)), field programmable logic device(s) (FPLD(s)), discrete logic, hardware, firmware, etc. Also, some or all of the example processes of FIGS. **7**A-**7**C, **8**, and **9** may be implemented manually or as any combination(s) of any of the foregoing techniques, for example, any combination of firmware, software, discrete logic and/or hardware. Further, although the example processes of FIGS. **7**A-**7**C, **8**, and **9** are described with reference to the flow diagrams of FIGS. **7**A-**7**C, **8**, and **9**, other methods of implementing the processes of FIGS. **7**A-**7**C, **8**, and **9** may be employed. For example, the order of execution of the blocks may be changed, and/or some of the blocks described may be changed, eliminated, sub-divided, or combined. Additionally, any or all of the example processes of FIGS. **7**A-**7**C, **8**, and **9** may be performed sequentially and/or in parallel by, for example, separate processing threads, processors, devices, discrete logic, circuits, etc.

Turning now to FIG. **7**A, the illustrated example process may be performed by the wireless terminal **114** during a

network discovery process. Initially, the wireless terminal **114** performs a wireless network scan (block **702**). For example, the wireless terminal **114** may perform a passive network scan in which it waits for one or more access points (e.g., one or more of the APs **104***a-c* of FIG. **1**) to broadcast its SSID (e.g., the SSID **212** of FIG. **2**) and encryption mode status (e.g., the encryption mode status **214** of FIG. **2**), if applicable. Alternatively, the wireless terminal **114** may perform an active scan in which the wireless terminal **114** transmits a probe request to actively solicit SSIDs (and encryption mode status and GAS support indicators) of any nearby WLANs.

The wireless terminal **114** determines whether any of its stored SSIDs match any of the SSIDs received at block **702** (block **704**). The stored SSIDs may be pre-stored by a user or a SSP or may have been previously stored by the wireless terminal **114** when received during a previous network discovery process. In some example implementations, the wireless network scan operations of blocks **702** and **704** may be omitted and the wireless terminal **114** may proceed to block **706** based on SSIDs that have been pre-stored in one of its memories (e.g., the FLASH memory **508** or the RAM **510** of FIG. **5**).

Of the WLANs identified as having SSIDs that match SSIDs stored in the wireless terminal **114**, the wireless terminal **114** selects the WLAN(s) that support(s) GAS (block **706**). For example, during the wireless network scan of block **702**, the wireless terminal **114** may receive GAS support indicators (e.g., the GAS support indicator **216** of FIG. **2**) indicating which WLANs support GAS.

The wireless terminal **114** uses an ANQP exchange to retrieve network capabilities for each WLAN selected at block **706** (block **710**). For example, for the WLAN associated with the AP **104***a* of FIGS. **1** and **2**, the wireless terminal **114** sends the NETCAP REQUEST **116** to the AP **104***a* and the AP **104***a* responds with the NETCAP RESPONSE **118** as discussed above in connection with FIGS. **1** and **2**. The wireless terminal **114** exchanges similar messages with any other WLAN selected at block **706**.

The wireless terminal **114** determines whether any of the WLANs advertised network capabilities that fully matched all of the network capabilities (e.g., the minimum capabilities **312** and the additional capabilities **314** of FIG. **3**) specified in a single network capabilities profile (e.g., the network capabilities profiles **210** of FIG. **2** and/or the network capabilities profiles of FIG. **3** and/or FIG. **4**) (block **712**). If the wireless terminal **114** finds full matches (block **712**), the wireless terminal **114** selects the WLAN that advertised network capabilities matching the network capabilities profile with the highest ranking relative to other matching profiles (block **714**). In some example implementations, the wireless terminal **114** may be configured to select a WLAN based on the network capabilities profile that has the relatively highest ranking and the closest proximity.

If at block **712**, the wireless terminal **114** does not find any full matches, the wireless terminal **114** determines whether any of the WLANs advertised network capabilities that partially match the network capabilities specified in a single network profile (e.g., the network capabilities profiles **210** of FIG. **2** and/or the network capabilities profiles **302** of FIG. **3** and/or **400** of FIG. **4**) (block **716**) (FIG. **7**B). If the wireless terminal **114** finds partial matches (block **716**), the wireless terminal **114** selects the WLAN(s) that advertised network capabilities that matched at least all of the minimum capabilities (e.g., the minimum capabilities **312** of FIG. **3** or **404** of FIG. **4**) of one or more network capabilities profile(s) (block **718**). If the wireless terminal **114** selected any WLAN at block **720**, the wireless terminal **114** then selects the WLAN that advertised network capabilities matching the minimum capabilities **312** (or the minimum capabilities **404**) of a network capabilities profile with the highest ranking (block **722**). In some example implementations, the wireless terminal **114** may be configured to select a WLAN based on the network capabilities profile that has the highest ranking and the closest proximity.

If the wireless terminal **114** did not select any WLAN at block **720** or if the wireless terminal **114** did not find any partial matches at block **716**, the wireless terminal **114** presents the available WLAN(s) discovered at block **702** to a user (block **724**). If the wireless terminal **114** receives a user selection of a WLAN (block **726**) or if the wireless terminal **114** selects a WLAN at block **722** or if the wireless terminal **114** selects a WLAN at block **714** (FIG. **7**A), the wireless terminal **114** joins with the selected WLAN (block **728**). In some example implementations, after joining the selected WLAN (block **728**), the wireless terminal **114** may also be registered with an external network (e.g., the external network A **108***a* of FIGS. **1** and **2**). As shown in FIG. **7**B, after joining the WLAN (block **728**) or if the wireless terminal **114** did not receive a user selection of a WLAN (e.g., within a timeout period) at block **726**, the example process of FIGS. **7**A-**7**C ends.

Returning to FIG. **7**A, if at block **704**, the wireless terminal **114** does not find that any of its stored SSIDs match any of the SSIDs received at block **702**, control advances to block **730** shown in FIG. **7**C. The wireless terminal **114** presents the available WLAN(s) discovered at block **702** via a display of the wireless terminal **114** (block **730**). If the wireless terminal **114** receives a user selection of one or more WLANs (block **732**) that the user would like to attempt to join, the wireless terminal **114** selects the WLAN(s) that support(s) GAS (block **734**). For example, the wireless terminal **114** may determine which WLANs support GAS based on which WLANs transmitted the GAS support indicator **216** (FIG. **2**) (e.g., based on GAS support indicators received at block **702**).

The wireless terminal **114** uses an ANQP exchange to retrieve network capabilities for each WLAN selected at block **734** (block **736**). For example, for the WLAN associated with the AP **104***a* of FIGS. **1** and **2**, the wireless terminal **114** sends the NETCAP REQUEST **116** to the AP **104***a* and the AP **104***a* responds with the NETCAP RESPONSE **118** as discussed above in connection with FIGS. **1** and **2**. The wireless terminal **114** exchanges similar messages with any other WLAN selected at block **736**.

The wireless terminal **114** presents the network capabilities retrieved at block **736** for each WLAN via a display of the wireless terminal **114** (block **738**). If the wireless terminal **114** receives a user selection of a WLAN (block **740**), the wireless terminal **114** joins the selected WLAN (block **742**). In some example implementations, after joining the selected WLAN (block **742**), the wireless terminal **114** may also be registered with an external network (e.g., the external network A **108***a* of FIGS. **1** and **2**). As shown in FIG. **7**C, after association with the selected WLAN (block **742**) or if the wireless terminal **114** did not receive one or more user selection(s) of WLAN(s) at block **732** (e.g., within a particular timeout period) or did not receive a user selection at block **740** (e.g., within a particular timeout period), the example process of FIGS. **7**A-**7**C ends.

Turning now to FIG. **8**, the flow diagram depicts another example process that may be performed by the wireless terminal **114** of FIGS. **1**-**5** to discover network capabilities available via one or more WLANs. Initially, the wireless terminal **114** performs a wireless network scan (block **802**). For

example, the wireless terminal **114** may perform a passive network scan in which it waits for one or more access points (e.g., one or more of the APs **104***a-c* of FIG. **1**) to broadcast its SSID (e.g., the SSID **212** of FIG. **2**) and encryption mode status (e.g., the encryption mode status **214** of FIG. **2**), if applicable. Alternatively, the wireless terminal **114** may perform an active scan in which the wireless terminal **114** transmits a probe request to actively solicit SSIDs (and encryption mode status and GAS support indicators) of any nearby WLANs.

If the wireless terminal **114** determines that one or more WLANs were discovered (block **804**), the wireless terminal **114** retrieves network services for each discovered WLAN (block **806**). For example, the wireless terminal **114** may use an ANQP exchange to retrieve the network services (e.g., the discovered network capabilities **304** of FIG. **3**) for each discovered WLAN that supports GAS. The wireless terminal **114** filters the received network services (block **808**). For example, the wireless terminal **114** may filter out any WLANs that do not meet the minimum network capabilities (e.g., the minimum capabilities **312** of FIG. **3** or **404** of FIG. **4**) specified in the wireless terminal **114** and may further filter the remaining WLANs based on rankings (e.g., the rankings **310** of FIG. **3**) associated with those minimum network capabilities. In this manner, the wireless terminal **114** can determine which of the WLANs are suitable candidates to join.

The wireless terminal **114** presents the network services via a display (block **810**) for each WLAN that it identified as being a suitable candidate for joining. If the wireless terminal **114** determines that one or more of the presented services were selected (e.g., by a user of the wireless terminal **114**) (block **812**), the wireless terminal **114** joins the WLAN that provides the one or more selected service(s) (block **814**).

At some time after joining the WLAN at block **814**, the wireless terminal **114** may determine whether it should discover other available networks (block **816**). For example, the network capabilities needs of the wireless terminal **114** may change or the wireless terminal **114** may become disconnected from the WLAN that it joined at block **814**. Additionally, the wireless terminal **114** may determine whether to discover other available networks at block **816** in instances when the wireless terminal **114** does not discover a network at block **804** or one or more services are not selected at block **812**. If the wireless terminal **114** determines that it should discover another network (block **816**), control passes back to block **804**. Otherwise, the example process of FIG. **8** ends.

Turning now to FIG. **9**, the illustrated example process may be performed by the AP **104***a* during a network discovery process. The example process may be similarly performed by any other AP (e.g., the APs **104***b* and **104***c* of FIG. **1** or any other AP) during a network discovery process. Initially, the AP **104***a* transmits its SSID (e.g., the SSID **212** of FIG. **2**) and any encryption mode status (e.g., the encryption mode status **214** of FIG. **2**) and GAS support indicator (e.g., the GAS support indicator **216** of FIG. **2**) (block **902**). The AP **104***a* may send this information based on a periodic SSID broadcast for passive network discovery scans or based on an active network discovery scan initiated by a wireless terminal (e.g., the wireless terminal **114** of FIGS. **1-5**).

If the AP **104***a* receives a network capabilities request (e.g., the NETCAP REQUEST **116** of FIGS. **1** and **2**) (block **906**), the AP **104***a* determines whether to forward a network capabilities request (e.g., the EXT-NETCAP REQUEST **218** of FIG. **2**) to an external network (e.g., the external network A **108***a* of FIGS. **1** and **2**) (block **906**). For example, if the AP **104***a* is in communication with an external network, it may send a network capabilities request to the external network. Otherwise, if it is not in communication with an external network, it does not send a network capabilities request to an external network.

If the AP **104***a* determines that it should send a network capabilities request to an external network (e.g., the external network A **108***a*) (block **906**), the AP **104***a* sends the EXT-NETCAP REQUEST **218** to the external network A **108***a* (block **908**) and receives the EXT-NETCAP RESPONSE **220** from the external network A **108***a* (block **910**) including network capabilities of the external network A **108***a* as described above in connection with FIG. **2**. After receiving the network capabilities of the external network A **108***a* at block **910** or if the AP **104***a* determines at block **906** that it should not send a network capabilities request to an external network, the AP **104***a* collects network capabilities of the access network A **106***a* (FIGS. **1** and **2**) (block **912**). The AP **104***a* generates the NETCAP RESPONSE **118** (FIGS. **1** and **2**) (block **914**) to include the network capabilities of the access network A **106***a* and/or the external network A **108***a* and sends the NETCAP RESPONSE **118** to the wireless terminal **114** (block **916**).

After sending the NETCAP RESPONSE **118** at block **916** or if the AP **104***a* has not received the NETCAP REQUEST **116** at block **904**, the AP **104***a* determines whether it should send another SSID (block **918**), for example, based on a periodic SSID broadcast or a request from a wireless terminal. If the AP **104***a* determines that it should send another SSID, control returns to block **902**. Otherwise, the AP **104***a* determines whether it should end its processes (block **920**), for example, based on a power off event or a low-power mode event. If the AP **104***a* should not end its processes, control returns to block **904**. Otherwise, the example process of FIG. **9** is ended.

Although certain methods, apparatus, and articles of manufacture have been described herein, the scope of coverage of this patent is not limited thereto. To the contrary, this patent covers all methods, apparatus, and articles of manufacture fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents.

What is claimed is:

1. A method for selecting a network, the method comprising:

determining network capabilities at a wireless terminal by:

scanning for wireless local area networks (WLANs); and

performing discovery Access Network Query Protocol (ANQP) exchanges to determine a list of network capabilities of access points of WLANs;

comparing the list of network capabilities with at least a portion of credentials;

finding a match between at least a portion of the list of network capabilities and at least the portion of the credentials;

filtering out the list of network capabilities that do not match at least the portion of the credentials; and

joining the wireless terminal with an access network associated with an access point of a WLAN based on the at least the portion of the list of network capabilities matching the at least the portion of the credentials.

2. The method as defined in claim **1**, wherein filtering out includes a remaining list of network capabilities ordered by preference which the wireless terminal has previously configured.

3. The method as defined in claim **2**, wherein the preference assigned to the network capabilities pertains to the wireless terminal.

4. The method as defined in claim 1, wherein the discovery ANQP exchanges include queries performed at the wireless terminal and the subsequent responses received from the access points based on determining that the access points support ANQP.

5. The method as defined in claim 1, wherein the credentials are credentials of the wireless terminal.

6. An apparatus for network selection, the apparatus comprising:

a processor to:

determine network capabilities at a wireless terminal by:

scanning for wireless local area networks (WLANs); and

performing discovery Access Network Query Protocol (ANQP) exchanges to determine a list of network capabilities of access points of WLANs;

compare the list of network capabilities with at least a portion of credentials;

find a match between at least a portion of the list of network capabilities and at least the portion of the credentials;

filter out the list of network capabilities that do not match at least the portion of the credentials; and

join the wireless terminal with an access network associated with an access point of a WLAN based on the at least the portion of the list of network capabilities matching the at least the portion of the credentials.

7. The apparatus as defined in claim 6, wherein filtering out includes a remaining list of network capabilities ordered by preference which the wireless terminal has previously configured.

8. The apparatus as defined in claim 7, wherein the preference assigned to the network capabilities pertains to the wireless terminal.

9. The apparatus as defined in claim 6, wherein the discovery ANQP exchanges include queries performed at the wireless terminal and the subsequent responses received from the access points when the access points support ANQP.

10. The apparatus as defined in claim 6, wherein the credentials are credentials of the wireless terminal.

11. A non-transitory tangible machine readable storage medium comprising instructions that, when executed, cause a machine to:

determine network capabilities at a wireless terminal by:

scanning for wireless local area networks (WLANs); and

performing discovery Access Network Query Protocol (ANQP) exchanges to determine a list of network capabilities of access points of WLANs;

compare the list of network capabilities with at least a portion of credentials;

find a match between at least a portion of the list of network capabilities and at least the portion of the credentials;

filter out the list of network capabilities that do not match at least the portion of the credentials; and

join the wireless terminal with an access network associated with an access point of a WLAN based on the at least the portion of the list of network capabilities matching the at least the portion of the credentials.

12. The non-transitory tangible machine readable storage medium as defined in claim 11, wherein filtering out includes a remaining list of network capabilities ordered by preference which the wireless terminal has previously configured.

13. The non-transitory tangible machine readable storage medium as defined in claim 12, wherein the preference assigned to the network capabilities pertains to the wireless terminal.

14. The non-transitory tangible machine readable storage medium as defined in claim 11, wherein the discovery ANQP exchanges include queries performed at the wireless terminal and the subsequent responses received from the access points when the access points support ANQP.

15. The non-transitory tangible machine readable storage medium as defined in claim 11, wherein the credentials are credentials of the wireless terminal.

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