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Kamath et al.

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(54) **SECURED CREDENTIAL SHARING OVER WI-FI PROTECTED SETUP**

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H04W 4/80	(2018.01)
H04W 12/73	(2021.01)
H04W 84/12	(2009.01)
H04W 92/10	(2009.01)
H04W 88/04	(2009.01)

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

CPC ***H04W 12/06*** (2013.01); ***H04W 4/80*** (2018.02); ***H04W 12/73*** (2021.01); ***H04W 84/12*** (2013.01); ***H04W 92/10*** (2013.01); *H04W 88/04* (2013.01)

(58) **Field of Classification Search**

CPC H04W 4/50–60; H04W 76/00–25
See application file for complete search history.

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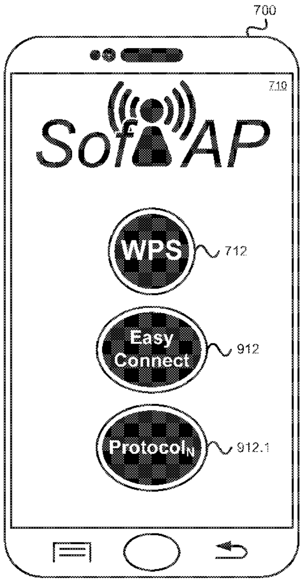
Primary Examiner — San Htun

(57) **ABSTRACT**

A method, apparatus, and system for providing temporary access point (AP) functionality to an intermediary device to provide wireless network credentials to a wireless device (STA) to be connected to a wireless network including an AP is described. The intermediary device may mimic the AP to provide wireless network credentials to the wireless device and discontinue an onboarding session to allow the wireless device to access the AP directly.

17 Claims, 9 Drawing Sheets



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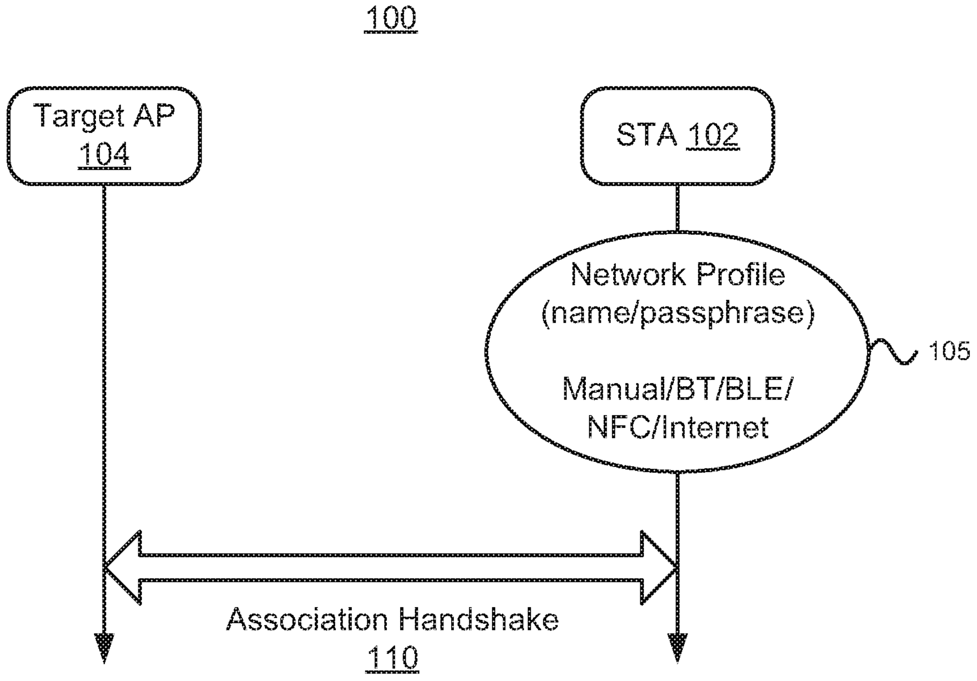

100
Target AP 104
STA 102
Network Profile (name/passphrase)
Manual/BT/BLE/ NFC/Internet
105
Association Handshake 110

FIGURE 1

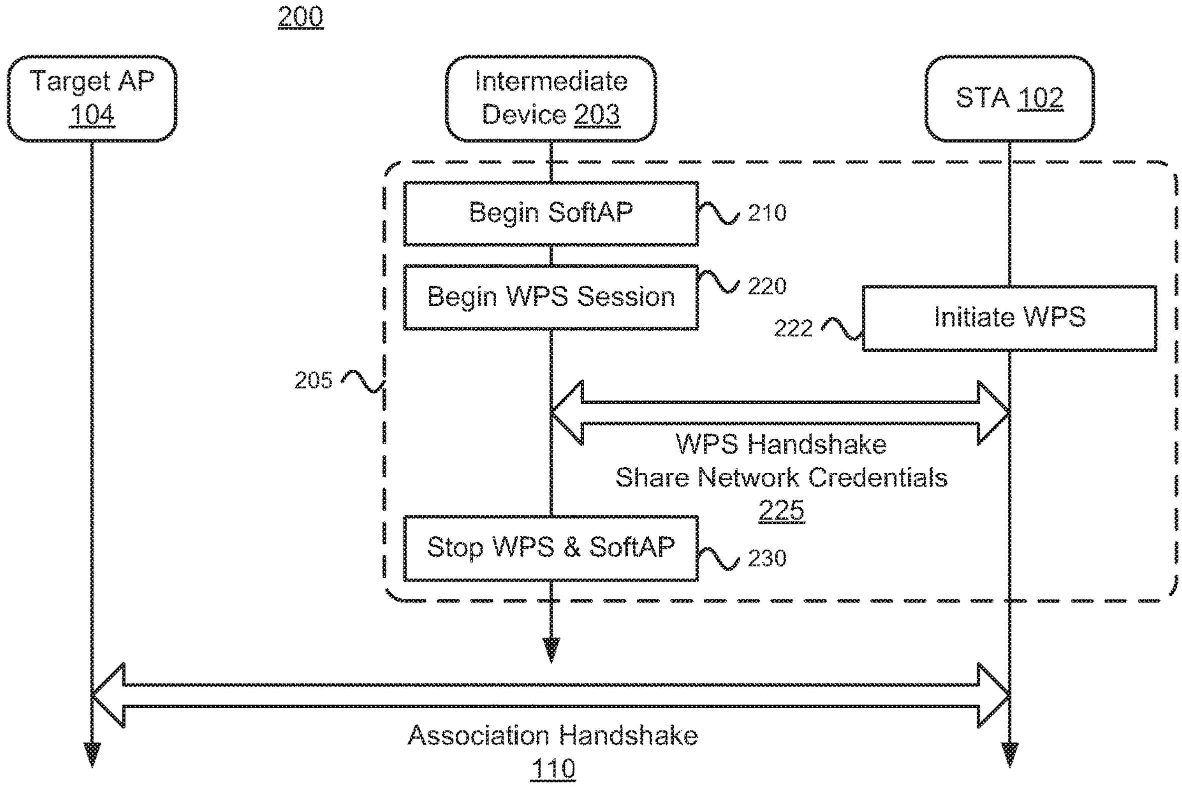

200
Target AP 104
Intermediate Device 203
STA 102
Begin SoftAP
210
Begin WPS Session
220
Initiate WPS
222
205
WPS Handshake
Share Network Credentials
225
Stop WPS & SoftAP
230
Association Handshake
110

FIGURE 2

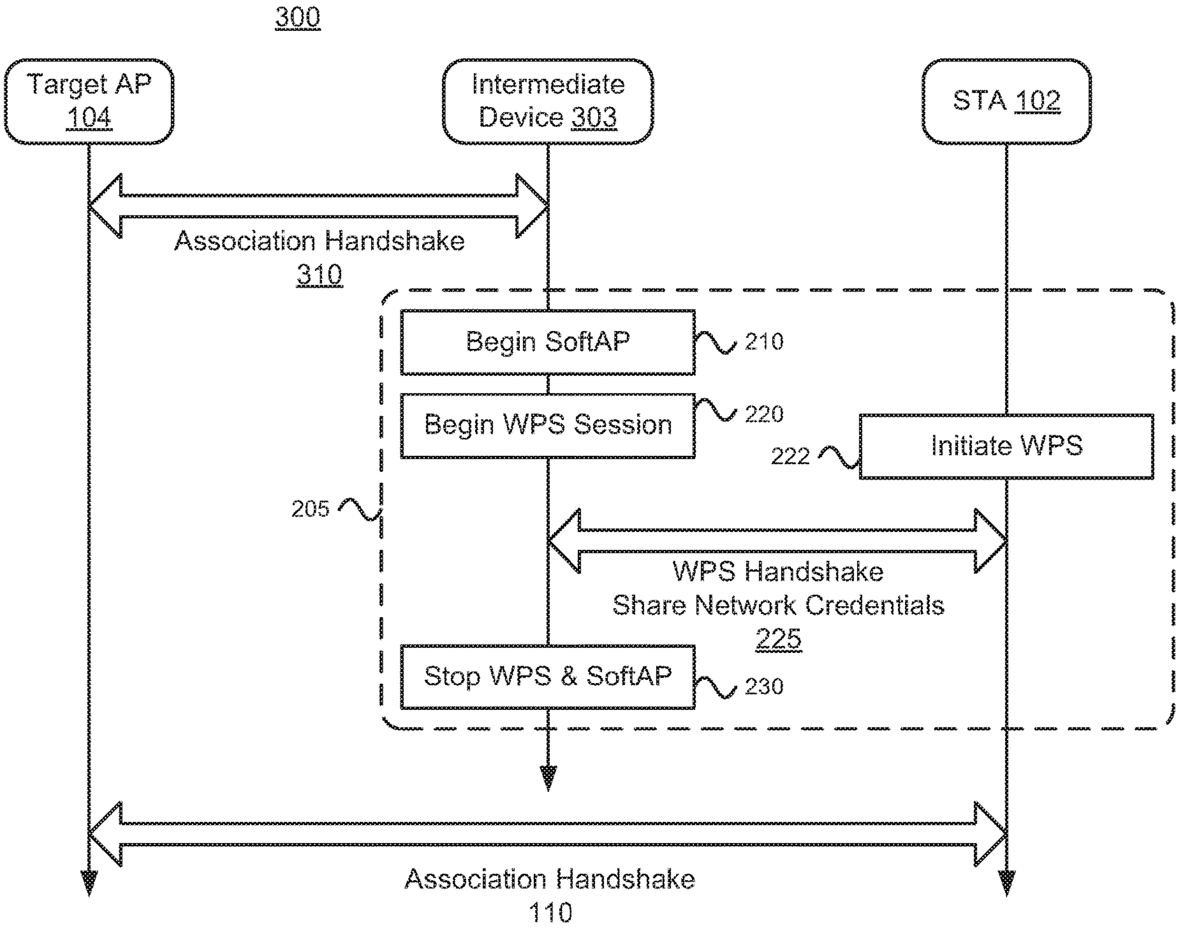

300
Target AP 104
Intermediate Device 303
STA 102
Association Handshake 310
Begin SoftAP
210
Begin WPS Session
220
Initiate WPS
222
205
WPS Handshake Share Network Credentials 225
Stop WPS & SoftAP
230
Association Handshake 110

FIGURE 3

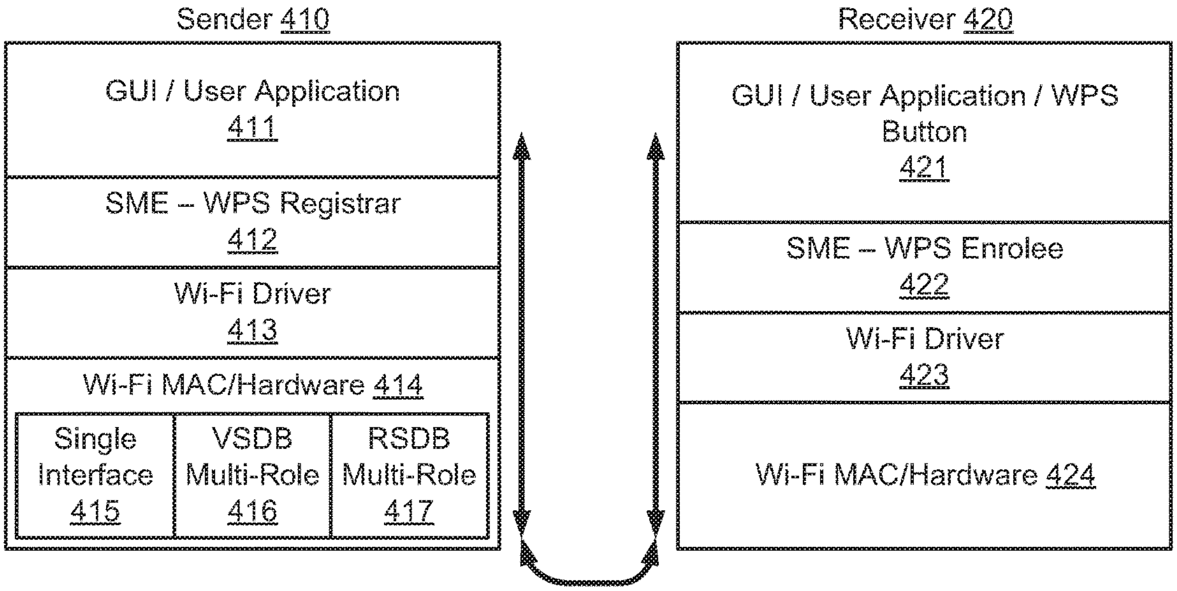

Sender 410
GUI / User Application 411
SME – WPS Registrar 412
Wi-Fi Driver 413
Wi-Fi MAC/Hardware 414
Single Interface 415
VSDB Multi-Role 416
RSDB Multi-Role 417
Receiver 420
GUI / User Application / WPS Button 421
SME – WPS Enrolee 422
Wi-Fi Driver 423
Wi-Fi MAC/Hardware 424

FIGURE 4

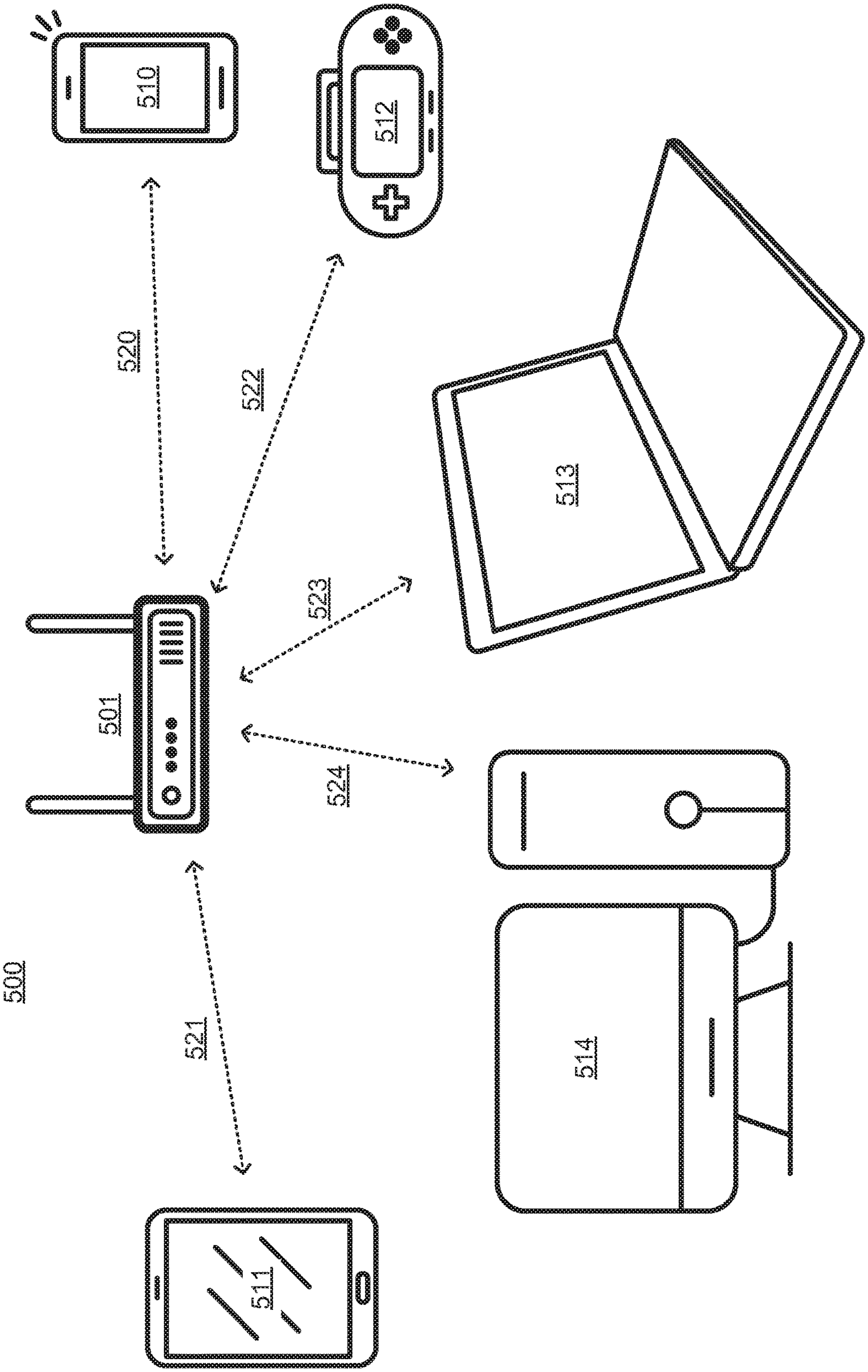
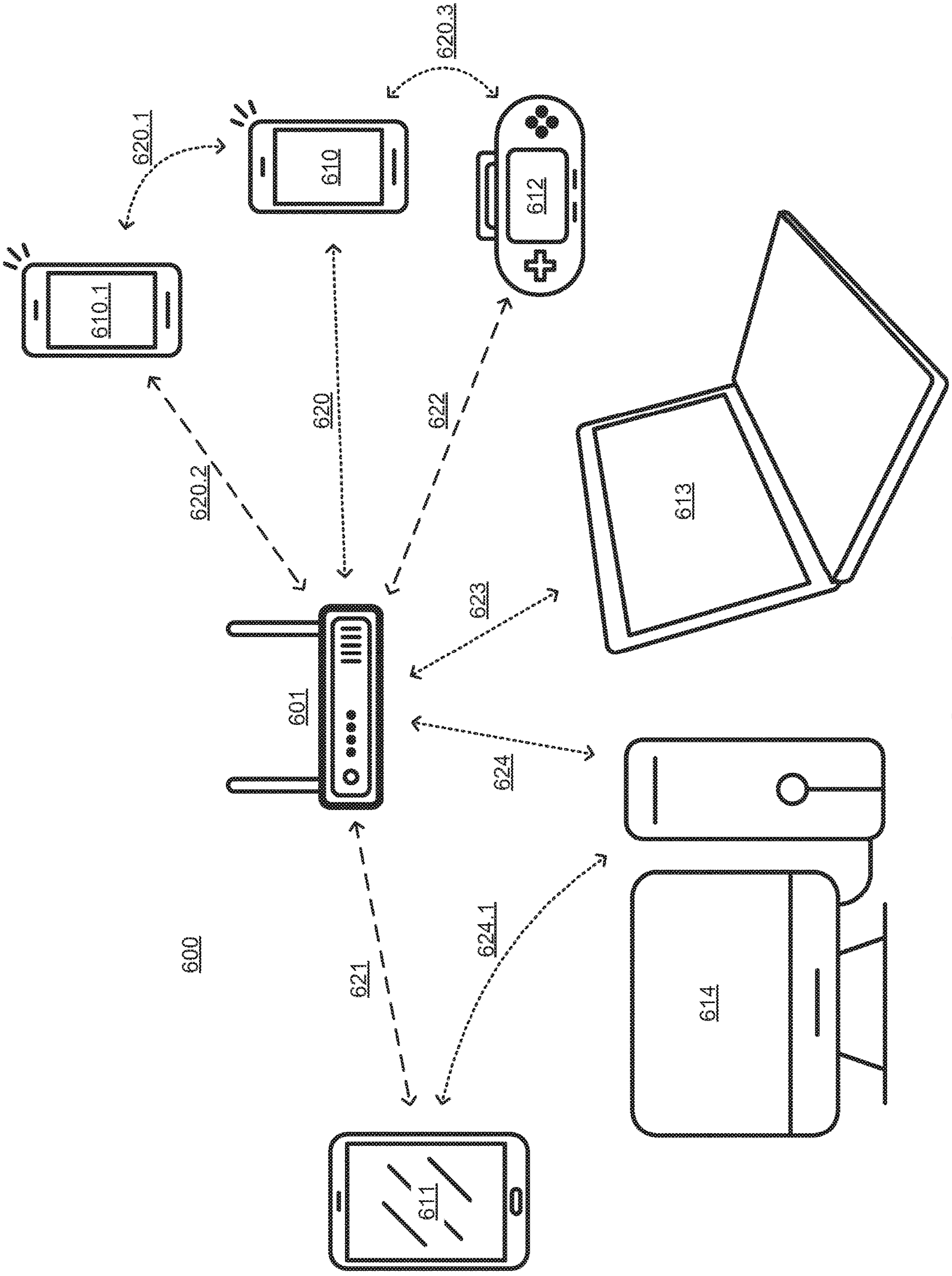


FIGURE 5


600
601
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624.1

FIGURE 6

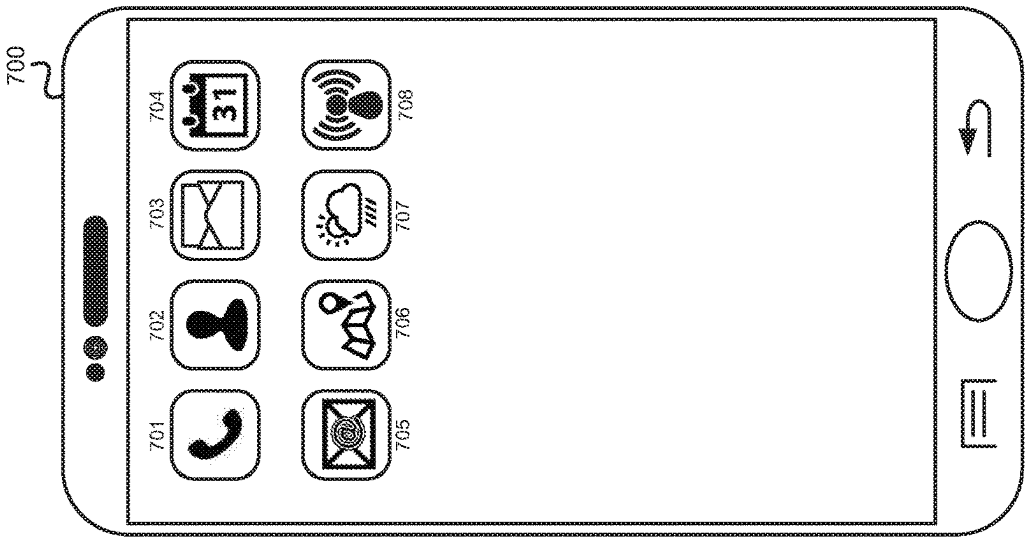


FIGURE 7A

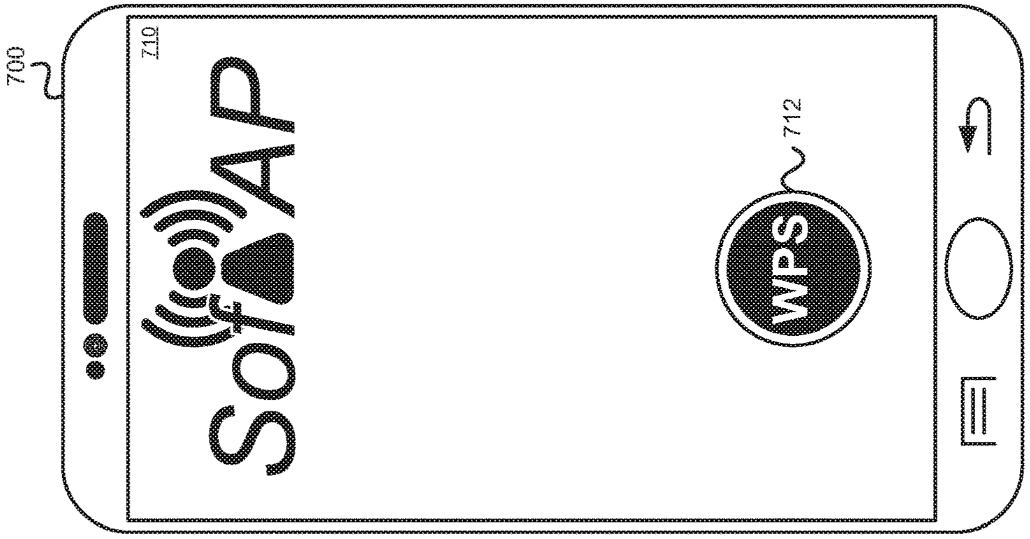


FIGURE 7B

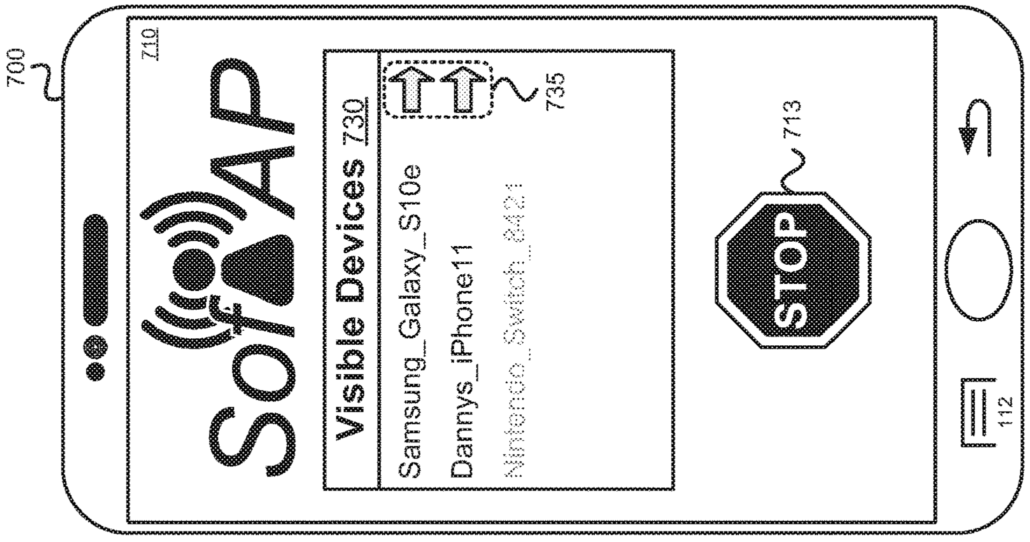


FIGURE 7C

FIGURE 8A

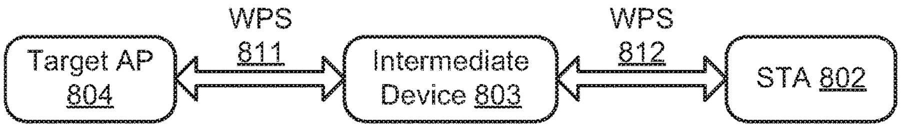


FIGURE 8B

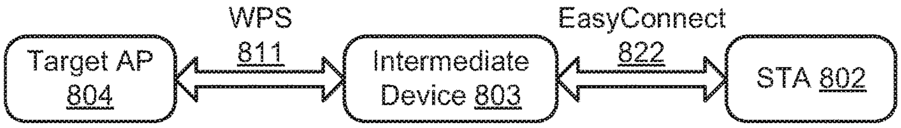


FIGURE 8C

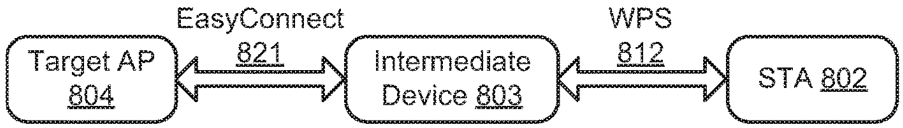


FIGURE 8D

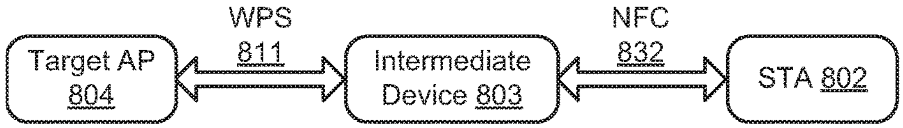


FIGURE 8E

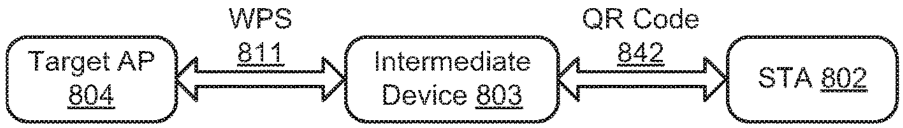
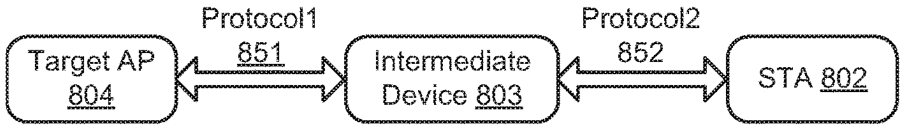


FIGURE 8F



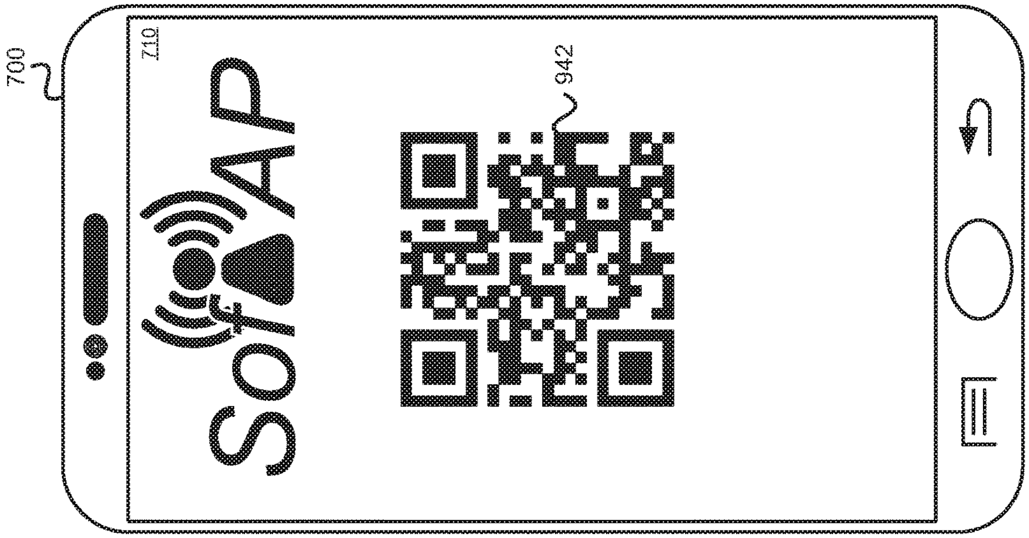


FIGURE 9C

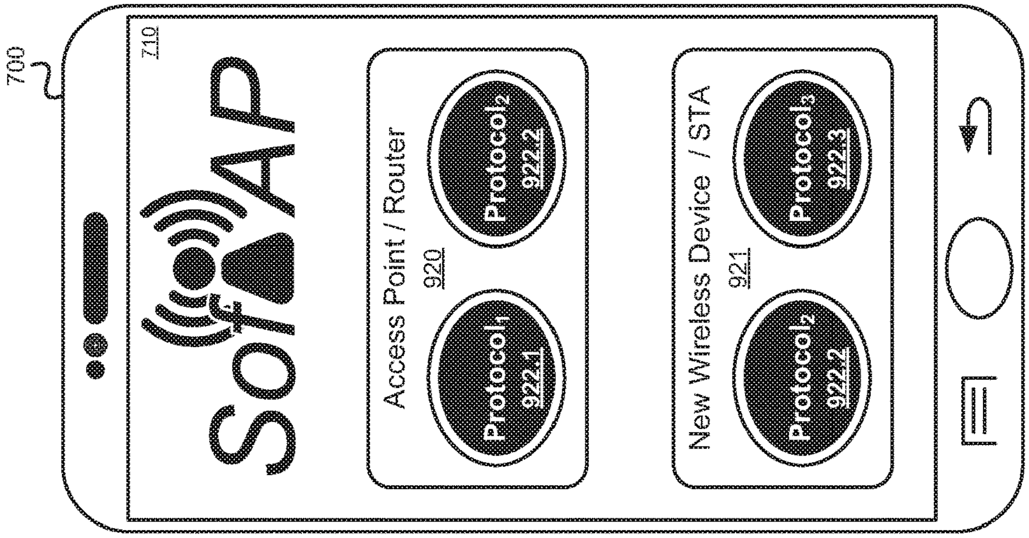


FIGURE 9B

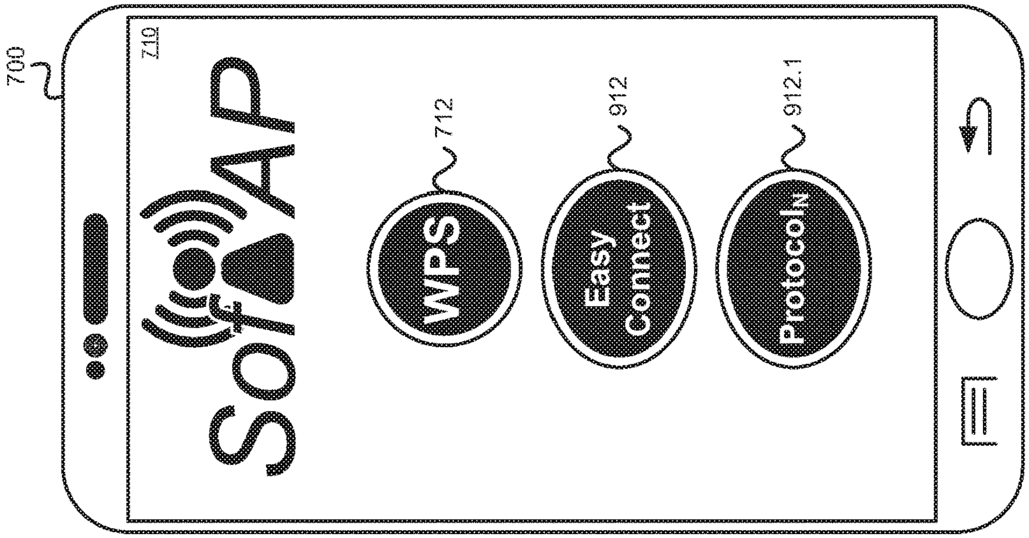


FIGURE 9A

SECURED CREDENTIAL SHARING OVER WI-FI PROTECTED SETUP

PRIORITY

This patent application claims priority to U.S. Provisional Patent Application No. 62/811,659, filed Feb. 28, 2019, which is incorporated herein by reference.

TECHNICAL FIELD

The described embodiments relate generally to wireless networking. More particularly, the described embodiments relate to methods, systems and apparatuses for onboarding a wireless device onto a secure wireless network.

BACKGROUND

Many companies are building products that benefit from a connection to a cloud service via the internet. For example, whitegoods manufacturers are connecting appliances like dishwashers and refrigerators to the internet to provide better customer service through remote access to the devices, and TV manufacturers are using internet connectivity to enable content streaming.

Wi-Fi (Wireless Fidelity) is becoming the predominant connectivity technology for consumer connected products as well as many industrial and commercial connected products.

However, connecting these devices to the internet through Wi-Fi is difficult for some consumers; sometimes consumers have trouble entering the credentials like SSID and password accurately, and in many cases the inconvenience of entering Wi-Fi credentials and the dislike of the process prevents customers from buying connected products in the first place. However, the model of Wi-Fi requires the Wi-Fi credentials to be put in the device in order to access the local network and the full bandwidth of the internet service. Onboarding a wireless device onto a secure network, such as Wi-Fi can be time consuming and require updates as Wi-Fi credentialing information is changed. This can be time consuming and inconvenient, and result in even more expensive support calls for manufacturers and internet service providers. Additionally, hardware-based methods, such as Wi-Fi Protected Setup (WPS) may require physical access to routers or other devices that is not optimal.

It is desirable to have a system, method and apparatus for providing wireless network credentials to wireless devices which is fast, can onboard multiple devices on the secure network with minimal latency, easy to set-up and requires minimal user-intervention. Such a system, method and apparatus will use a provisioning device (such as mobile phone) with which consumers are familiar and provides an increased level of security.

SUMMARY

An embodiment includes a method for providing wireless network credentials to a station (STA) by mimicking an access point (AP) by an intermediary device. The intermediary device may have previously paired with the AP and the mimicking may be by way or beginning a WPS session or a session of another protocol type, such as EasyConnect. A handshake between the intermediary device and the STA may establish a connection therebetween and by which wireless network credentials may be passed to the STA. Network credentials may also be provided to the STA via near-field communication (NFC). The intermediary device may then discontinue the WPS session (or a session of some other protocol type) to allow the STA to communicate with the AP. In one embodiment, the intermediary device may be in concurrent communication with both the AP and the STA. This concurrent communication may be enable by real-time simultaneous dual band (RSDB) or virtual simultaneous dual band (VSDB) operation of the intermediary device. The intermediary device may be further configured to provide network credentials to multiple STAs concurrently.

The method may further include the use of a graphical user interface (GUI) for displaying the status of the wireless network credential transfer, the available APs and STAs, and protocols that may be used for the transfer. The GUI may be displayed on a handheld device, such as a smart phone or mobile handset. The GUI may also be run on another computing device, such as a tablet, a desktop computer, or a laptop computer.

In another embodiment, a non-transitory, computer-readable medium may contain instructions for a controller of an intermediary device. The instructions may be used to provide wireless network credentials to a station (STA) by mimicking an access point (AP) by the intermediary device. The intermediary device may have previously paired with the AP and the mimicking may be by way or beginning a WPS session or a session of another protocol type, such as EasyConnect. A handshake between the intermediary device and the STA may establish a connection therebetween and by which wireless network credentials may be passed to the STA. Network credentials may also be provided to the STA via near-field communication (NFC). The intermediary device may then discontinue the WPS session (or a session of some other protocol type) to allow the STA to communicate with the AP. In one embodiment, the intermediary device may be in concurrent communication with both the AP and the STA. This concurrent communication may be enable by real-time simultaneous dual band (RSDB) or virtual simultaneous dual band (VSDB) operation of the intermediary device. The intermediary device may be further configured to provide network credentials to multiple STAs concurrently.

In another embodiment, a STA may be configured to access a wireless network including an AP upon receipt of valid wireless network credentials. An intermediary device, which may be previously associated with the AP, may provide wireless network credentials by mimicking the AP either with the same protocol used by the AP or by another protocol. A handshake between the intermediary device and the STA may establish a connection therebetween and by which wireless network credentials may be passed to the STA. Network credentials may also be provided to the STA via near-field communication (NFC). The intermediary device may then discontinue the WPS session (or a session of some other protocol type) to allow the STA to communicate with the AP. In one embodiment, the intermediary device may be in concurrent communication with both the AP and the STA. This concurrent communication may be enable by real-time simultaneous dual band (RSDB) or virtual simultaneous dual band (VSDB) operation of the intermediary device. The intermediary device may be further configured to provide network credentials to multiple STAs concurrently.

Other aspects and advantages of the described embodiments will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the described embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a scheme for providing secure network credentials from r a Target AP to a station, according to one embodiment.

FIG. **2** shows a scheme for providing secure network credentials from a Target AP to a station using an intermediate device mimicking the Target AP, according to one embodiment.

FIG. **3** shows a scheme for providing secure network credentials from a Target AP to a station using an intermediate device mimicking the Target AP while in operative communication with the Target AP, according to one embodiment.

FIG. **4** illustrates software/firmware/hardware stacks for senders and receivers of wireless network credential information, according to one embodiment.

FIG. **5** illustrates a system including multiple wireless devices in operative, wireless communication with a router, according to one embodiment.

FIG. **6** illustrates a system including multiple wireless devices in operative, wireless communication with a router, wherein at least one wireless device is configured to mimic the router to provide wireless network credential information to at least one other device, according to one embodiment.

FIGS. **7**A-C illustrate a graphical user interface (GUI) for enabling mimicking of a Target AP by an intermediate device for providing wireless network credential information to a station, according to one embodiment.

FIGS. **8**A-F illustrate various schemes for providing wireless network credentials to a station via an intermediate device over a variety of protocols, according to some embodiments.

FIGS. **9**A-C illustrate a graphical user interface (GUI) for enabling mimicking of a Target AP by an intermediate device for providing wireless network credential information to a station over a variety of protocols, according to various embodiments.

DETAILED DESCRIPTION

The following description sets forth numerous specific details such as examples of specific systems, components, methods, and so forth, in order to provide a good understanding of various embodiments of the communication schemes and techniques. It will be apparent to one skilled in the art, however, that at least some embodiments may be practiced without these specific details. In other instances, well-known components or methods are not described in detail or are presented in a simple block diagram format in order to avoid unnecessarily obscuring the techniques described herein. Thus, the specific details set forth hereinafter are merely exemplary. Particular implementations may vary from these exemplary details and still be contemplated to be within the spirit and scope of the present invention.

References in the description to "an embodiment", "one embodiment", "an example embodiment", "some embodiments", and "various embodiments" mean that the particular feature, structure, or characteristic being referred to is included in at least one embodiment of the invention. Further, the appearances of the phrases "an embodiment", "one embodiment", "an example embodiment", "some embodiments", and "various embodiments" in various places in the description do not necessarily all refer to the same embodiment(s).

In various embodiments, the communication schemes and techniques described herein may comprise one or more methods that are executed by one or more devices and/or controllers thereof. Although the operations of such method (s) are shown and described hereinafter in a particular order, the operations of each method may be altered so that certain operations may be performed in a different order or so that certain operation(s) may be performed, at least in part, concurrently and/or in parallel with other operations. In other embodiments, instructions or sub-operations of distinct operations may be executed in an intermittent and/or alternating manner. Thus, the various method embodiments of the described techniques, as well as the order of operations therein, are to be regarded in an illustrative rather than a restrictive sense.

The described embodiments include systems, methods, and apparatuses for onboarding a wireless device onto a secure network with an intermediate device.

Onboarding a wireless device onto a secure network may not have a rich user interface, creating difficulty in the process. The existing solutions—which are mostly based on local communication between wireless devices can be slow, difficult to set-up (and re set-up), requiring manual intervention and, hence, difficult to operate for multiple devices.

Networks, including home and local personal networks are often configured with layer-2 security such as Wi-Fi Protected Access (WPA), WPA2 or WPA3. Network configurations and credential information may be exchanged between devices, such as an access point (AP) and a station (STA) over a variety of out-of-band mediums, including Bluetooth (BT), Bluetooth Low Energy (BLE), near-field communication (NFC), and internet technologies. The network profile (network name and passphrase) may also be configured or entered manually by a user.

FIG. **1** illustrates a method **100** for provisioning of a STA **102** onto an AP **104**. The network profile information for AP **104** may be entered into STA **102** manually, or by another means (including BT, BLE, NFC or internet technologies) in step **105**. In one embodiment, delivery of the network credentials may use WiFi Protected Setup (WPS) methods. Association between STA **102** and AP **104** may then be completed using a 4-way handshake in step **110**. While a 4-way handshake is illustrated, one of ordinary skill in the art would recognize that more or fewer steps may be used, depending on the protocol. Once association is completed, STA **102** may be in operative and secure wireless communication with AP **104**.

FIG. **2** illustrates a method **200** for provisioning of a STA **102** onto a wireless network including Target AP **104** using an intermediary device **203**. Intermediary device **203** may ease the wireless network credential exchange between STA **102** and Target AP **104**. Intermediary device **203** may be a wireless local area network (WLAN) device that is already provisioned with the wireless network credentials of Target AP **104**. Intermediary device may mimic Target AP **104** in step **205** for a brief period to deliver the network credentials for Target AP **104** to STA **102**. In one embodiment, delivery of the network credentials may use WiFi Protected Setup (WPS) methods.

Mimicking Target AP **104** in step **205** may include beginning a software-enabled access point (softAP) in step **210**. A soft AP may allow the intermediary device to operate like an access point or a virtual router. In one embodiment the intermediary device **203** may then begin a secure credential provisioning protocol such as WPS in step **220**. With the WPS session begun, intermediary device **203** may begin beaconing and start the WPS registrar. STA **104** may then initiate a WPS session in step **222**. Initiation of the WPS may be via a graphical user interface (GUI) or through a mechanical WPS button on STA **102**. A WPS handshake in step **225** may be used to share the network credentials for Target AP **104**. Wireless access for STA **102** may be only to intermediary device **203** and may be temporary until the WPS session is terminated. The WPS handshake may include the intermediary device **203** running the basic service set (BSS) and WPS registrar for long enough to complete the WPS handshake Once network credentials are shared with STA **104**, intermediary device **203** may discontinue the softAP and WPS session in step **230**. Discontinuation of the BSS by the intermediary device **203** may allow STA **102** to connect automatically to Target AP **104**. Association between STA **102** and AP **104** may then be completed using a 4-way handshake in step **110** (as shown in FIG. **1**). While a 4-way handshake is illustrated, one of ordinary skill in the art would recognize that more or fewer steps may be used, depending on the protocol. This communication may occur directly between STA **102** and Target AP **104**. Once association is completed, STA **102** may be in operative and secure wireless communication with AP **104**.

To reduce or eliminate potential interference with devices already provisioned to and in operative communication with Target AP **104**, Intermediate Device **203** may only accept devices on its "network" that are in WPS mode, meaning that they are not roaming and are seeking new connection. In another embodiment, Intermediate Device **203** may reduce its transmit power so that its range of communication is low enough that only devices in close proximity are able to receive its beaconing. In still another embodiment, Intermediate Device **203** may only accept devices that are in WPS mode or similar secure credential provisioning mode and reduce its transmit power to reduce its effective range. Additional isolation methods may also be employed.

FIG. **3** illustrates a method **300** for provisioning of a STA **102** onto an AP **104** using an intermediary device **303** operating as a real-time simultaneous dual band (RSDB) or virtual simultaneous dual band (VSDB) device to mimic Target AP **104**. Intermediate device **303** may be in operative communication with Target AP **104** after association using a 4-way handshake in step **310**. While a 4-way handshake is illustrated, one of ordinary skill in the art would recognize that more or fewer steps may be used, depending on the protocol. Using RSDB or VSDB, Intermediate Device **303** may initiate a SoftAP in step **210** of the STA provisioning step **205** while remaining in operative communication with Target AP **104**. Intermediary device **303** may then begin a WPS session in step **220**. With the WPS session begun, intermediary device **303** may start beaconing and the WPS registrar. STA **104** may then initiate a WPS in step **222**. Initiation of the WPS may be via a GUI or through a mechanical WPS button. A WPS handshake in step **225** may be used to share the network credentials for Target AP **104**. The WPS handshake may include the intermediary device **303** running the basic service set (BSS) and WPS registrar for long enough to complete the WPS handshake. Once network credentials are shared with STA **104**, intermediary device **303** may discontinue the softAP and WPS in step **230**. Discontinuation of the BSS by the intermediary device **303** may allow STA **102** to connect automatically to Target AP **104**. Association between STA **102** and AP **104** may then be completed using a 4-way handshake in step **110**. While a 4-way handshake is illustrated, one of ordinary skill in the art would recognize that more or fewer steps may be used, depending on the protocol. This communication may occur directly between STA **102** and Target AP **104**. Once association is completed, both Intermediate Device **303** and STA **102** may be in operative and secure wireless communication with AP **104**.

FIG. **4** illustrates example software/firmware/hardware stacks for a sender station (sender) **410** and a receiver station (receiver) **420**. For sender **410**, there may be a gGUI/user application **411** which provides a user-friendly interface for configuration and control of network credentials. GUI **411** may provide a graphical representation of sender **410**'s operation mimicking the Target AP and provide a user with indications of the available devices, the status of credential transfer, and control over the WPS operation of the intermediate device (sender **410**). A supplicant management entity (SME) or WPS registrar **212** may be used to manage the devices on the wireless network. Information for the SME/WPS registrar **212** may be received by a Wi-Fi driver coupled to Wi-Fi MAC/hardware for transmission and receipt of wireless signals from and by the sender **410**. Wi-Fi MAC/Hardware **414** may include several interfaces depending on the various modes in which sender **410** may operate. Interfaces may include single communication interface **415**, which allows sender **410** to communicate with a Target AP or a STA, but not both at the same time. Interfaces may also include VSDB and RSDB multi-role interfaces **416** and **417**, which allow sender **410** to communicate with a Target AP and a STA simultaneously, or virtually simultaneously.

Receiver **420** may include similar software/firmware/hardware blocks as sender **410**. Wi-Fi MAC/Hardware **424** may be used to send/receive wireless signals to/from sender **410**. Wi-Fi driver **423** may be used to control Wi-Fi MAC/Hardware **424** and to convert signals received in Wi-Fi MAC/Hardware to digital information for sender **420**. SME-WPS Enrollee block **422** may be used to store wireless credential information received from Wi-Fi Driver **423**, and GUI/WPS Button **421** may be used as an interface between a user and the rest of the device for procuring network credentials.

FIG. **5** illustrates a wireless system **500**, wherein wireless devices (STAs) are provisioned onto a router (Target AP) individually. Wireless devices may include a mobile handset (smartphone) **510**, a tablet **511**, a portable gaming device **512**, a laptop computer **513**, or a desktop computer **514**. While only one of each type of wireless device is illustrated, one or ordinary skill would understand that multiple of each wireless device may be connected to router **501**. Additionally, not all of the types of wireless device need be connected to router **500**. Still further, device types not shown, but that would be connected to router **500** are also possible in FIG. **5**, although now shown for ease of illustration and explanation. Connections of each wireless device to router **501** are illustrated as connections **520-524**. In wireless system **500**, each wireless device **510-514** must receive its credentials from router **501** itself. If WPS is used, router **501** must be reached by a user to activate the WPS beacon. Two scenarios may occur: either router **501** is inaccessible, or router **501** may be accessible, but not as easily as desired. If a new device, for example, another smartphone similar to smartphone **510** is desired to provision onto a wireless network including router **501** using WPS, there may be no way to complete the provisioning the new device without physically touching router **501**.

FIG. **6** illustrates a wireless system **600**, wherein wireless devices may be provisioned onto a wireless network including router **601** using WPS without physical contact with router **601**. Mobile handset (smart phone) **610**, laptop computer **613**, and desktop computer **614** may be in operative communication with router **601** over wireless connections

620, **623**, and **624**, respectively. Provisioning on mobile handset **610**, laptop computer **613** and desktop computer **624** may be completed using WPS or some other method (see FIG. **1**). But for the purposes of explanation of FIG. **6**, they are each already provisioned onto the wireless network including router **601** as the AP. If a new wireless handset **610.1** is within range of and wants to join the network including router **601**, wireless handset **610** may mimic router **601** as described in FIG. **2** or **3**. A wireless connection **620.1** may be established between wireless handset **610** and wireless handset **610.1**. Wireless handset **610** may appear to wireless handset **610.1** as router **601** and may provide wireless network credentials for router **601** to wireless handset **610.1**. Upon delivery of the wireless network credentials, wireless handset **610** may terminate WPS operation and the SoftAP, as described with regard to FIGS. **2** and **3**, and wireless handset **610.1** may associate with router **601** over wireless connection **620.2**.

Wireless handset **610** may also be used to provision onto the wireless network of router **601** portable gaming device **612**. As with wireless handset **610.1**, portable gaming device **612** may connect to wireless handset **610** over wireless connection **620.3** when wireless handset **610** is mimicking router **601**. The wireless network credentials for router **601** may then be provided to portable gaming device **312** before wireless handset **610** terminates WPS operation and the SoftAP. Portable gaming device **612** may then connect to router **601** over wireless connection **620.4**.

In one embodiment, the delivery of wireless network credentials for router **601** may be completed in series for each device wirelessly connected to mobile handset **610**. That is, mobile handset **610** may mimic router **601** and pass wireless network credentials to only one new wireless device at a time. A new WPS session may begin for each new STA to be provided wireless network credentials. In another embodiment, mobile handset **610** may provide wireless network credentials to all new wireless devices simultaneously or concurrently and as needed, as long as the SoftAP and WPS sessions are active.

Also in FIG. **6**, desktop computer **614**, which is in operative communication with router **601** may be used to provide network credentials to tablet **611**. Desktop computer **614** may mimic router **601** using a SoftAP and WPS session, establishing a wireless connection **624.1** with tablet **611**. Once wireless network credentials are delivered to tablet **611**, desktop computer **614** may terminate the SoftAP and WPS session and tablet **611** may associate with router **601** over wireless connection **621** using the wireless network credentials provided by desktop computer **614**.

The system **600** of FIG. **6** may be particularly useful when security configuration information (such as WPA2-Personal with AES encryption) is complex. If a user wishes to provide access to a local network quickly to another user, who is in possession of a device not on the local network, the use of WPS methodology allows for quicker and easier transfer of wireless network credential information.

FIGS. **7A-7C** illustrate a mobile handset **700** configured to mimic a Target AP and provide wireless network credentials to a STA as described in FIGS. **2**, **3**, and **6** above. In FIG. **7A**, an application ("app") may be provided to instruct mobile handset **700** to mimic the Target AP. Along with apps for the mobile handset **700** to operate as a phone (**701**), address book (**702**), SMS/text interface (**703**), day planner/calendar (**704**), email client (**705**), map/GPS (**706**), and weather station interface (**707**), a SoftAP app (**708**) may also be provided. When a user selects the SoftAP app **708**, a GUI (FIG. **7B**; **710**) may be opened to allow the user to control the mobile handset **700** as the SoftAP.

FIG. **7B** illustrates one embodiment of the SoftAP app **710** running on mobile handset **700**. The SoftAP app **710** may include a software WPS button **712** shown on the LCD of mobile handset **700**. When a user presses WPS button **712**, mobile handset may begin the SoftAP and the WPS session for nearby devices that are not already in operative wireless communication with an AP (not shown; described in FIGS. **2**, **3**, and **6**).

FIG. **7C** illustrates operation of the SoftAP app **710** on mobile handset **700**. A list of visible device **730** may be displayed to allow a user to select devices that he/she wishes to provision onto the wireless network of the Target AP (such as router **601** of FIG. **6**). A further GUI element **735** for passing wireless network credentials to new wireless devices may provide incremental control of provisioning. In another embodiment, a single "deliver" button may be provided and credentials may be passed to all devices that are visible to the mobile handset **700**. In still another embodiment, wireless network credentials may be passed to new wireless devices automatically, with no additional input from the user other than the initiation of the SoftAP and WPS session. The SoftAP app may also include a "stop" button **713** for terminating the WPS session. Pressing the stop button **713** may merely terminate the WPS session in one embodiment. App **710** may remain open and new WPS session may be begun by pressing WPS button **712** again. In another it may terminate the WPS session and the SoftAP. The user may then provision additional devices by again selecting the SoftAP app **708** as shown in FIG. **7A**.

The GUI of FIGS. **7A-7C** may be used with existing hardware. In fact, a software change for the mobile handset (or any device that may be configured to mimic the Target AP) is all that is required. Furthermore, sharing of network credentials with a new STA by the intermediate device (mobile handset) need not require connection with the AP. Credentials may be provided to a wireless device (STA) even if the intermediate device is not on the wireless network for the AP (such as router **601**). In this embodiment, app **710** may have an additional GUI element for selecting with network (or AP) for which wireless network credentials may be sent.

While the above description details a method for providing wireless network credentials using WPS for both the Target AP and the STA, through the Intermediary Device, in other embodiments, different protocols may be used for the interface between the Target AP and the Intermediary Device, for the interface between the Intermediary Device and the STA, or both.

FIGS. **8A-F** illustrate various embodiments for providing wireless network credentials for a Target AP **804** to a STA **802** through an Intermediary Device **803**.

FIG. **8A** illustrates the method described in FIGS. **2** and **3**, wherein Intermediary Device **803** mimics Target AP **804**, which is configured to provide wireless credentials over a WPS protocol **811**. Intermediary Device **803** therefor provides wireless network credentials to STA **802** over WPS protocol **812**.

FIG. **8B** illustrates a method wherein Target AP **804** communicates wireless network credentials over a WPS protocol **811**, but STA **802** receives wireless network credentials over an EasyConnect protocol **822**. In this scheme, the Target AP **804** and STA **802** may not be configured to communicate directly. The STA may not be able to receive wireless network credentials over WPS and the Target AP may not be able to transmit wireless network credentials over EasyConnect. Intermediary Device **803**, therefore, operates as a bridge between Target AP **804** and STA **802**, communicating with Target AP **804** over a WPS protocol **811** and with STA **802** over an EasyConnect protocol **822**.

FIG. **8**C illustrates a method wherein Target AP **804** communicates wireless network credentials over an EasyConnect protocol **821**, but STA **802** receives wireless network credentials over a WPS protocol **822**. This is the mirror image of the method of FIG. **8**B. In this scheme, the Target AP **804** and STA **802** may not be configured to communicate directly. The STA may not be able to receive wireless network credentials over EasyConnect and the Target AP may not be able to transmit wireless network credentials over WPS. Intermediary Device **803**, therefore, operates as a bridge between Target AP **804** and STA **802**, communicating with Target AP **804** over an EasyConnect protocol **821** and with STA **802** over a WPS protocol **812**.

FIG. **8**D illustrates a method wherein Target AP **804** communicates wireless network credentials over a WPS protocol **811**, but STA **802** receives wireless network credentials over a near-field communication (NFC) protocol **832**. In this scheme, the Target AP **804** and STA **802** may not be configured to communicate directly. The STA may not be able to receive wireless network credentials over WPS and the Target AP may not be able to transmit wireless network credentials over NFC, or may be too distant from STA **802** for NFC to function property. Intermediary Device **803**, therefore, operates as a bridge between Target AP **804** and STA **802**, communicating with Target AP **804** over a WPS protocol **811** and with STA **802** over an NFC protocol **822**.

FIG. **8**E illustrates a method wherein Target AP **804** communicates wireless network credentials over a WPS protocol **811**, but STA **802** receives wireless network credentials by scanning a QR code **842** that may be displayed in Intermediary Device **803**. In this scheme, the Target AP **804** and STA **802** may not be configured to communicate directly. The STA may not be able to receive wireless network credentials over WPS and the Target AP may not be accessible to provide a QR code, or may lack an interface through which to provide a visual display of the wireless network credentials. Intermediary Device **803**, therefore, operates as a bridge between Target AP **804** and STA **802**, communicating with Target AP **804** over a WPS protocol **811** and providing network credentials to STA **802** via QR code **842**.

The specifics of the above schemes are intended as examples, only. FIG. **8**F illustrates a method where a first protocol **851** is used to communicate between Target AP **804** and Intermediary Device **803** and a second protocol **852** is used to communicate between Intermediary Device **803** and STA **802**. The reasons and mechanisms for the different protocols may vary. In various instances, Target AP **804** and STA **802** may not be able to communicate directly because of hardware/firmware/software incompatibilities. Target AP **804** may be too far away from STA **802** for protocols that require proximity. The devices may be operating under different standards, having been developed, released, or installed at different times. An intermediary device that is capable or communicating with both the Target AP and the STA may serve as a bridge to enable the transmission of wireless network protocols between devices that would be otherwise incapable of such.

FIGS. **9**A-C illustrates various embodiments of SoftAP app **710** for mobile handset **700**, as described above with regard to FIGS. **7**A-C, but with additional functionality corresponding to FIGS. **8**A-F.

FIG. **9**A illustrates SoftAP app **710** with multiple options for the communication of wireless network credentials. These options may include a WPS button, as described above with regard to FIG. **7**B. The options may also include an EasyConnect button **912** for communication between a Target AP and a STA through an Intermediary Device over EasyConnect, instead of WPS. The options may further include another protocol (Protocol$_N$) **912.1**. Protocol$_N$ **912.1** may be any protocol that is used to communicate wireless network credentials, as described with regard to FIG. **8**F.

FIG. **9**B illustrates the SoftAP app **710**, wherein the protocol for communication between the Intermediary Device and the Target AP can be selected from a menu **920** of various protocols (e.g. Protocol$_1$ **922.1** and Protocol$_2$ **922.2**). While two protocols are shown, one of ordinary skill in the art would understand that more or fewer than two protocols may be included in menu **920**. Menu **921** may be used to provide options for communication between the Intermediary Device and the STA. These protocols may include Protocol$_2$ **922.2** and Protocol$_3$ **922.3**. In one embodiment, menus **920** and **921** may share at least one protocol (in this case, Protocol$_2$ **922.2**). But in other embodiments, there may be no overlap. The available protocols for communication with the Target AP and the STA may not coincide.

FIG. **9**C illustrates the SoftAP app **710** configured to display a QR code **942** corresponding to the wireless network credentials for the Target AP, corresponding to the method shown in FIG. **8**E. The STA may then image the QR code **942** to store the wireless network credentials locally for use in onboarding to the Target AP.

In the various embodiments of FIGS. **8**A-F and FIGS. **9**A-C, Intermediary Device **803** may be used to bridge communication between Target AP **804** and STA **802**. This bridge may be to overcome protocol mismatches, physical/spatial availability, or usability concerns between Target AP **80** and STA **802**.

As used herein, the term "coupled to" means connected directly, or connected indirectly through one or more intervening components over PCB tracks/pads, switches, buses, hubs, trace lines, and/or programmable interconnects, as the case may be. Any of the signals provided through various PCB tracks/pads, switches, hubs, traces, and programmable interconnects may be time multiplexed with other signals and provided over one or more common or dedicated buses and/or signal traces. Each of the buses may alternatively include one or more single signal traces, and one or more signal traces may alternatively perform the function of a bus.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

What is claimed is:

1. A method for providing wireless network credentials to a station (STA) comprising:
   - mimicking an access point (AP) by an intermediary device, the intermediary device having previously paired with the AP, wherein mimicking the AP includes beginning a WPS session on the intermediary device;
   - performing, by the intermediary device, a WPS handshake with the STA;
   - upon completion of the WPS handshake, providing, by the intermediary device, network credentials to the STA;

terminating the WPS session on the intermediary device; and

terminating mimicking of the AP by the intermediary device, wherein the intermediary device is a handheld device for displaying a graphical user interface GUI for initiating a soft AP session and a WPS handshake with the STA.

2. The method of claim **1**, wherein the intermediary device is in concurrent operative communication with the AP and the STA.

3. The method of claim **2**, wherein simultaneous operative communication with the AP and the STA by the intermediary device is by real-time simultaneous dual band (RSDB) or virtual simultaneous dual band (VSDB) operation of the intermediary device.

4. The method of claim **1**, wherein network credentials are passed to the STA without input from the AP.

5. The method of claim **1**, wherein the intermediary device is configured to provide network credentials to multiple stations (STAs) simultaneously.

6. The method of claim **1**, further comprising, prior the providing network credentials, retrieving the network credentials for the AP stored in a memory location of the intermediary device.

7. The method of claim **1**, wherein mimicking an AP comprises providing AP functionality by the intermediary device.

8. A non-transitory, computer-readable medium containing instructions for a controller of an intermediary device, the instructions for:

mimicking an access point (AP) by an intermediary device, the intermediary device having previously paired with the AP, wherein mimicking the AP includes beginning a WPS session on the intermediary device;

performing, by the intermediary device, a WPS handshake with the STA; upon completion of the WPS handshake, providing, by the intermediary device, network credentials to the STA;

terminating the WPS session on the intermediary device; and

terminating mimicking of the AP by the intermediary device,

wherein the intermediary device is a handheld device for displaying a graphical user interface GUI for initiating a soft AP session and a WPS handshake with the STA.

9. The non-transitory, computer-readable medium of claim **8**, wherein the intermediary device is in concurrent operative communication with the AP and the STA.

10. The non-transitory, computer-readable medium of claim **9**, wherein simultaneous operative communication with the AP and the STA by the intermediary device is by real-time simultaneous dual band (RSDB) or virtual simultaneous dual band (VSDB) operation of the intermediary device.

11. The non-transitory, computer-readable medium of claim **8**, further comprising instructions for providing the graphical user interface (GUI) for initiation of the WPS session.

12. The non-transitory, computer-readable medium of claim **8**, wherein instructions contained therein allow network credentials to be passed to the STA without input from the AP.

13. The non-transitory, computer-readable medium of claim **8**, further including instructions to allow the intermediary device is configured to provide network credentials to multiple stations (STAs) simultaneously.

14. The non-transitory, computer-readable medium of claim **8**, further comprising instructions for the retrieval of network credentials for the AP stored in a memory location of the intermediary device prior to providing the network credentials to the STA.

15. A system comprising:

a station (STA) configured to access a wireless network upon receipt of valid network credentials; and

an intermediary device, the intermediary device previously associated with the wireless network, wherein the intermediary device is configured to:

provide access point (AP) functionality corresponding to an access point of the wireless network,

provide network credentials to the STA while mimicking the AP, and

terminate a soft AP session over which network credentials to the STA are provided, the termination of the soft AP session to allow the STA to associate with the AP,

wherein the intermediary device is a handheld device for displaying a graphical user interface GUI for initiating a soft AP session and a WPS handshake with the STA.

16. The system of claim of claim **15**, wherein the intermediary device has a first wireless communication range that is less than a second wireless communication range of the AP.

17. The system of claim **15**, wherein the intermediary device is capable of operative communication with the AP as a STA simultaneous to operative communication with the STA as an AP.

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