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Ganesan

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(54) **MOBILE TELEPHONE VOIP/CELLULAR SEAMLESS ROAMING SWITCHING CONTROLLER**

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H04W 36/14 (2009.01)

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CPC ***H04W 60/04*** (2013.01); ***H04W 36/14*** (2013.01); *H04W 36/18* (2013.01); *H04W 80/04* (2013.01); ***H04W 88/18*** (2013.01); *H04W 92/02* (2013.01)
USPC **455/432.1**; 455/436; 455/338; 370/331; 370/332; 370/380

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See application file for complete search history.

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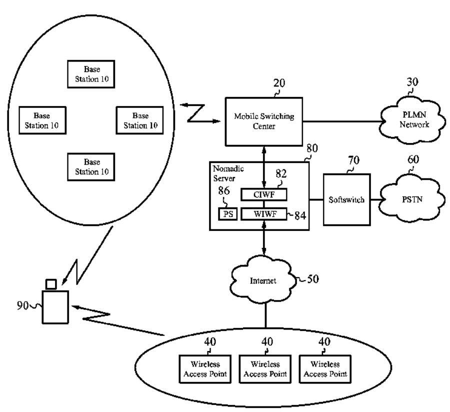
(57) **ABSTRACT**

A nomadic server and a related system provides seamless roaming for a mobile communication device between different types of wireless networks, such as WiFi and cellular networks for voice, data and video communication. Use of the nomadic server enables a combination of WiFi and cellular networks for providing access to cellular phones and make use of the VOIP networks for switching the calls wherever possible. The nomadic server is a telephone communication processing and switching server that will "hold" the present, in-progress telephone communications without dropping, while roaming without losing the present, in-progress communication. For example, a telephone communication can be seamlessly switching between VOIP and cellular telephone networks using the nomadic server. Nomadic server resources interface with the VOIP and cellular network switches to provide the hand-off between networks. This approach enables switching of telephone communications over a VOIP network wherever possible either through WiFi or through cellular networks.

13 Claims, 4 Drawing Sheets



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H04W 60/04	(2009.01)
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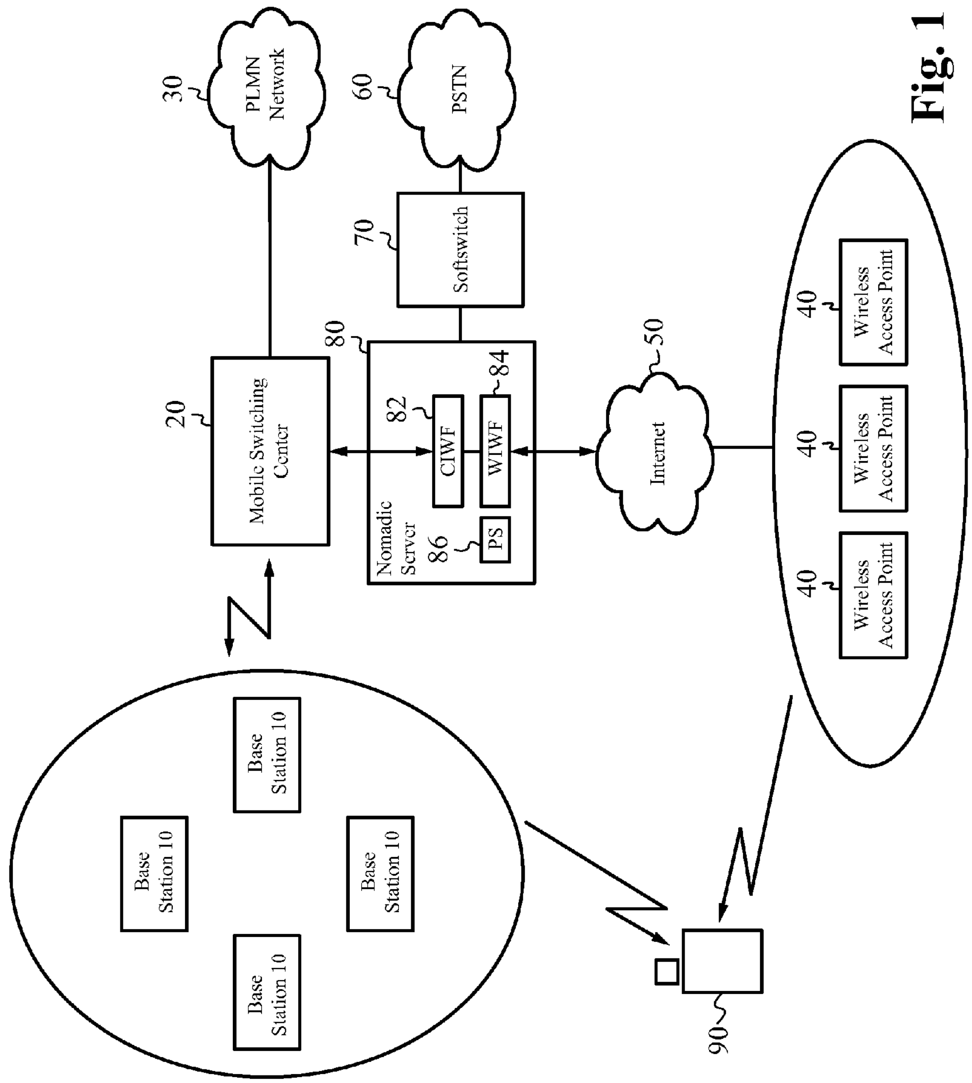
30
PLMN Network
60
PSTN
70
Softswitch
20
Mobile Switching Center
80
Nomadic Server
82
CIWF
84
WIWF
86
PS
50
Internet
40
Wireless Access Point
40
Wireless Access Point
40
Wireless Access Point
Base Station 10
Base Station 10
Base Station 10
Base Station 10
90

Fig. 1

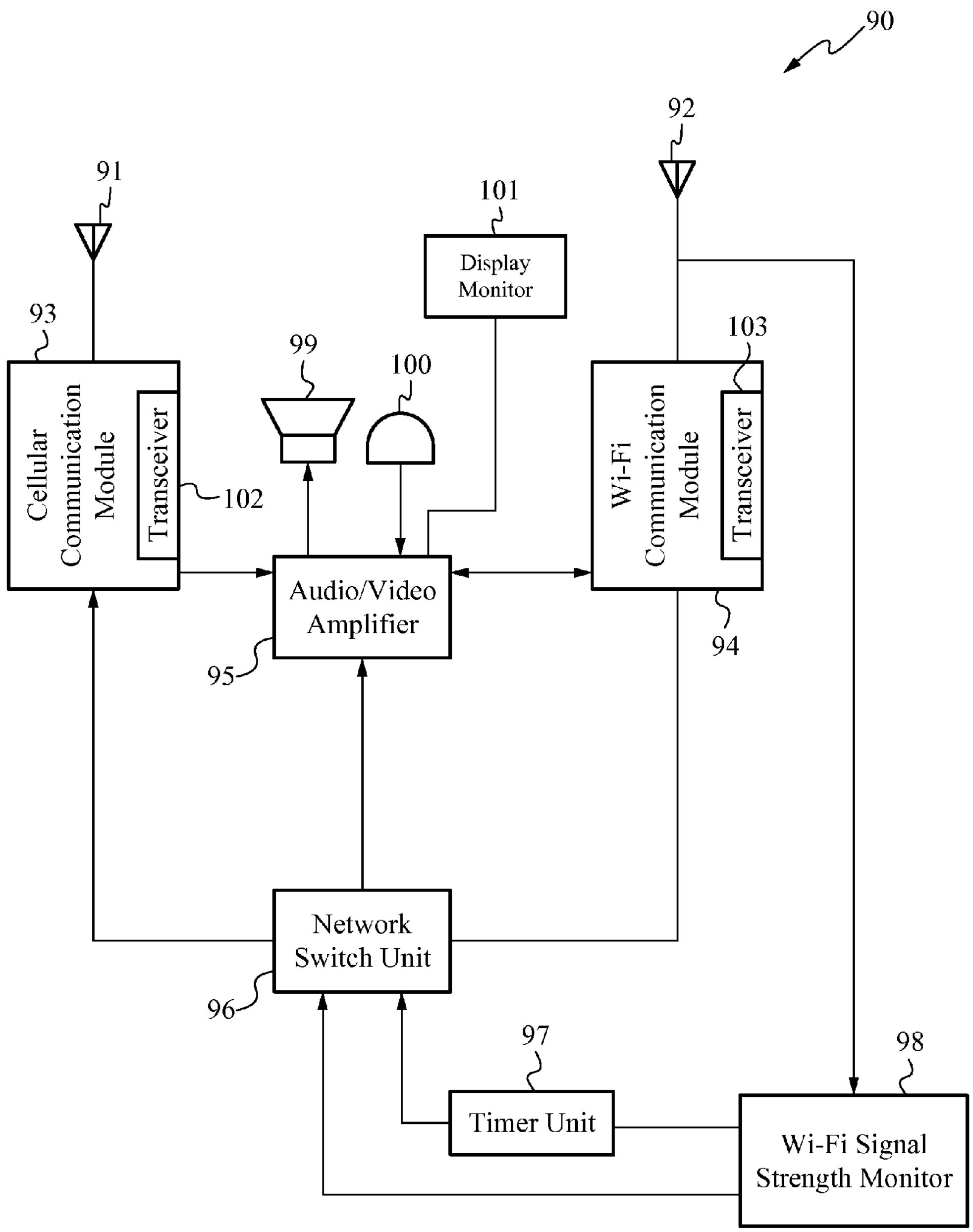
90
92
91
101
Display Monitor
93
103
99
100
Cellular Communication Module
Transceiver
102
Wi-Fi Communication Module
Transceiver
Audio/Video Amplifier
94
95
Network Switch Unit
96
97
98
Timer Unit
Wi-Fi Signal Strength Monitor

Fig. 2

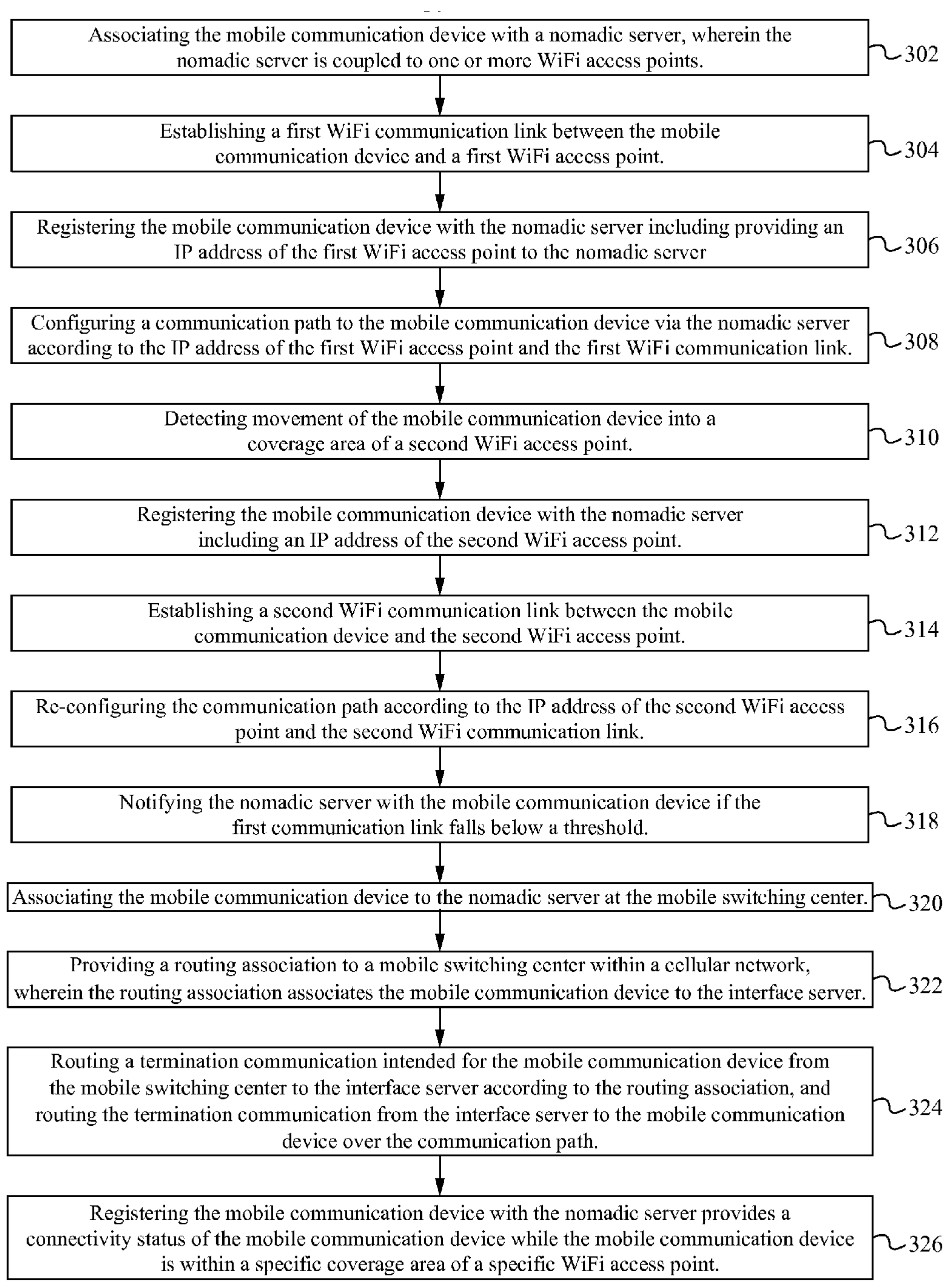
Associating the mobile communication device with a nomadic server, wherein the nomadic server is coupled to one or more WiFi access points.
302
Establishing a first WiFi communication link between the mobile communication device and a first WiFi access point.
304
Registering the mobile communication device with the nomadic server including providing an IP address of the first WiFi access point to the nomadic server
306
Configuring a communication path to the mobile communication device via the nomadic server according to the IP address of the first WiFi access point and the first WiFi communication link.
308
Detecting movement of the mobile communication device into a coverage area of a second WiFi access point.
310
Registering the mobile communication device with the nomadic server including an IP address of the second WiFi access point.
312
Establishing a second WiFi communication link between the mobile communication device and the second WiFi access point.
314
Re-configuring the communication path according to the IP address of the second WiFi access point and the second WiFi communication link.
316
Notifying the nomadic server with the mobile communication device if the first communication link falls below a threshold.
318
Associating the mobile communication device to the nomadic server at the mobile switching center.
320
Providing a routing association to a mobile switching center within a cellular network, wherein the routing association associates the mobile communication device to the interface server.
322
Routing a termination communication intended for the mobile communication device from the mobile switching center to the interface server according to the routing association, and routing the termination communication from the interface server to the mobile communication device over the communication path.
324
Registering the mobile communication device with the nomadic server provides a connectivity status of the mobile communication device while the mobile communication device is within a specific coverage area of a specific WiFi access point.
326

Fig. 3

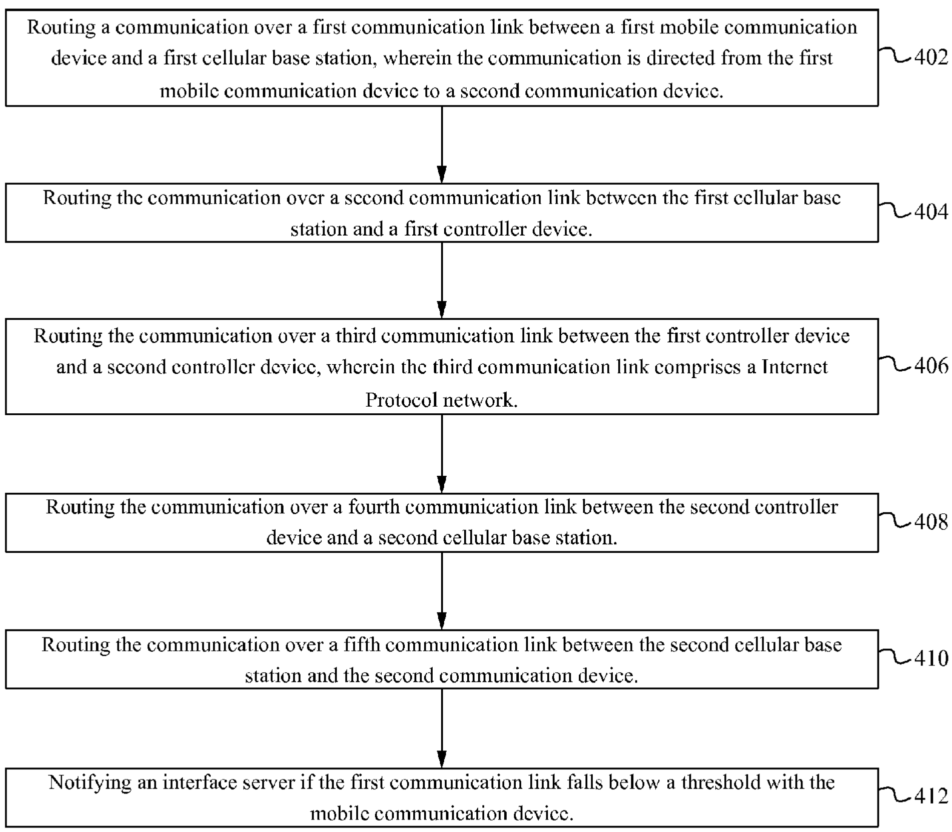
Routing a communication over a first communication link between a first mobile communication device and a first cellular base station, wherein the communication is directed from the first mobile communication device to a second communication device.
402
Routing the communication over a second communication link between the first cellular base station and a first controller device.
404
Routing the communication over a third communication link between the first controller device and a second controller device, wherein the third communication link comprises a Internet Protocol network.
406
Routing the communication over a fourth communication link between the second controller device and a second cellular base station.
408
Routing the communication over a fifth communication link between the second cellular base station and the second communication device.
410
Notifying an interface server if the first communication link falls below a threshold with the mobile communication device.
412

Fig. 4

MOBILE TELEPHONE VOIP/CELLULAR SEAMLESS ROAMING SWITCHING CONTROLLER

RELATED APPLICATIONS

This Patent Application is a divisional application of co-pending U.S. patent application Ser. No. 11/330,675, filed on Jan. 11, 2006, and entitled "MOBILE TELEPHONE VOIP/CELLULAR SEAMLESS ROAMING SWITCHING CONTROLLER," which claims priority of U.S. provisional application Ser. No. 60/643,829, filed Jan. 14, 2005, and entitled "TELEPHONE COMMUNICATIONS PROCESSING CONTROLLER," by the same inventors and is a continuation-in-part of U.S. patent application Ser. No. 11/031,498, filed Jan. 6, 2005, now U.S. Pat. No. 7,991,399 and entitled "TELEPHONE WITH AUTOMATIC SWITCHING BETWEEN CELLULAR AND VOIP NETWORKS", all of which are hereby incorporated by reference. U.S. patent application Ser. No. 11/031,498 claims priority of U.S. provisional application Ser. No. 60/534,466, filed Jan. 6, 2004, and entitled "RADIOTELEPHONE WITH AUTOMATIC SWITCHING BETWEEN CELLULAR AND WI-FI NETWORKS USING WI-FI SIGNAL STRENGTH VALUES," the content of which is also incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to the field of network communication processing. In particular, the present invention relates to seamlessly switching communications among Voice over Internet (VOIP), public cellular, and public circuit switched networks.

BACKGROUND OF THE INVENTION

Current telephone communications occur over wireless cellular networks, such as GSM, CDMA, and CDMA2000, Voice Over Internet (VOIP), or circuit switched network, such as PSTN. Current state of the art of most telephones used with such networks is that each telephone is restricted for use with only one specific network. For example, a cellular phone works in a cellular network; a VOIP phone works in VOIP network, and a landline phone works in a circuit switched network. Such limitations imply that an in-progress telephone communication cannot be seamlessly switched among cellular, VOIP, and circuit switched networks without losing the connection.

Such wireless networks use regulated portions of the radio spectrum and are shared by many users. The infrastructure costs of wireless networks are relatively high due to the size and complexity of the network equipment. There is a wide variance in the performance of different wireless networks. For example, a conventional wireless cellular network covers a relatively large geographical area, but provides a relatively low bandwidth. Other wireless networks, such as CDMA2000-EV-DO/DV networks, offer higher bandwidth and enhanced data services, such as web browsing. However, these networks also pack many users into a relatively small portion of the regulated spectrum. Other types of wireless networks are adapted to improve spectral efficiency with increased speed and smaller coverage areas. For example, an IEEE 802.11x (or WiFi) network may transmit at speeds up to 11 Mbps using a Direct Sequence Spread Spectrum (DSSS) mode or at speeds up to 54 Mbps using an Orthogonal Frequency Division Multiplexing (OFDM) mode.

A network wireless access point conforming to a WiFi (e.g., IEEE 802.11b) network may cover an area of a few hundred feet in diameter. Each such network access point is connected to a larger network (e.g., Internet). One such example is WiFi VOIP (Wireless Fidelity Voice over Internet Protocol), through which a communication device user can place a wireless telephone call over the Internet, using the technology specified in IEEE 802.xx at the network access point. VOIP is a method for taking analog audio signals and converting them into digital data that can be transmitted over the Internet. Conventional VOIP telephone communications are enabled by VOIP network carriers, which utilize VOIP networks (e.g. the Internet), to place VOIP based telephone calls. VOIP enabled and compatible networks include VOIP switching for proper routing and billing of VOIP based telephone calls.

In order to cover larger geographical areas, a relatively large number of IEEE 802.11x, for example, network access points and relatively large wire-line back haul networks are required. In part, due to the relatively small geographical coverage area of each network access point, the resulting IEEE 802.11x based network may thus be prohibitively expensive to set up. Further, the small coverage areas may lead to many "dead zones" in which mobile communication device users are unable to place telephone calls using the VOIP network.

Conventional VOIP phones, which function in a WiFi coverage area (hotspot) corresponding to a WiFi access point, offers relatively inexpensive telephone communications. However, the WiFi availability is limited due to the small geographical area supported by each WiFi access point.

Conventional cellular phones, which function in a cell coverage area within the cellular network, are relatively expensive for telephone communications and have limited multimedia capabilities. Cellular networks and availability to the network covers a much wider, extensive geographical area.

Conventional landline phones, which function in a circuit switched network such as most residences, do not offer extensive telephone communication features, for example video. Such landline phones also do not offer the mobility provided by mobile communications devices such as the VOIP phones or the cellular phones.

SUMMARY OF THE INVENTION

The present invention is directed to an interface server, referred to as a nomadic server, and a related system that provides seamless roaming of a mobile communication device between different types of wireless networks, such as WiFi and cellular networks for voice, data and video communication. Use of the nomadic server enables a combination of WiFi and cellular networks for providing access to the mobile communication device and makes use of the VOIP networks for switching the calls wherever possible.

The nomadic server is a telephone communication processing and switching server that will "hold" the present, in-progress telephone communications without dropping, while roaming between WiFi access points and cellular networks, without losing the present, in-progress communication. For example, a telephone communication can be seamlessly switched between VOIP and cellular telephone networks using the nomadic server. Nomadic server resources interface with the VOIP and cellular network switches to provide the hand-off between networks. This approach enables switching of telephone communications over a VOIP network wherever possible either through WiFi or through cellular networks.

In one aspect of the present invention, a method provides communications for a mobile communication device that roams between multiple different types of wireless networks. The method comprises establishing a first communication link between the mobile communication device and an end destination device, wherein the first communication link includes a first wireless communication link between the mobile communication device and a first type of wireless network, monitoring a signal strength of the first wireless communication link, when the signal strength drops below a predetermined threshold, establishing a second communication link between an interface server and the end destination device, notifying the mobile communication device to terminate transmission over the first communication link, and redirecting the second communication link from the interface server to the mobile communication device, thereby establishing a second wireless communication link between the mobile communication device and the second type of wireless network. The first type of wireless communication link can comprise a WiFi communication link, and the first type of wireless network can include a WiFi network access point. The second type of wireless network can include a wireless cellular network. Establishing the first communication link can include routing through a VOIP network. Establishing the first communication link can include routing through a cellular network. Establishing the second communication link can include routing through a VOIP network. Establishing the second communication link can include routing through a cellular network.

The method can also include providing a connectivity status by the mobile communication device to the interface server while the mobile communication device is within a first coverage area of the first type of wireless network. The method can also include providing a routing association to a mobile switching center within the second type of wireless network, wherein the routing association associates the mobile communication device to the interface server. The method can also include routing a termination communication intended for the mobile communication device from the mobile switching center to the interface server according to the routing association when the connectivity status is active, and routing the termination communication from the interface server to the mobile communication device over the first type of wireless network. The method can also include when the connectivity status is not provided to the interface server, the router association is removed from the mobile switching center. The method can also include registering the mobile communication device with a mobile switching center within the second type of wireless network when the signal strength drops below the predetermined threshold. The method can also include setting up the second communication link with the end destination device and forwarding the second communication link to the interface server.

In another aspect of the present invention, a method provides communications for a mobile communication device that roams between multiple WiFi coverage areas. The method includes associating the mobile communication device with a nomadic server, wherein the nomadic server is coupled to one or more WiFi access points, establishing a first WiFi communication link between the mobile communication device and a first WiFi access point, registering the mobile communication device with the nomadic server including providing an IP address of the first WiFi access point to the nomadic server, configuring a communication path to the mobile communication device via the nomadic server according to the IP address of the first WiFi access point and the first WiFi communication link, detecting movement of the mobile communication device into a coverage area of a second WiFi access point, registering the mobile communication device with the nomadic server including an IP address of the second WiFi access point, establishing a second WiFi communication link between the mobile communication device and the second WiFi access point, and re-configuring the communication path according to the IP address of the second WiFi access point and the second WiFi communication link. The method can also include associating the mobile communication device to the nomadic server at the mobile switching center. The method can also include providing a routing association to a mobile switching center within a cellular network, wherein the routing association associates the mobile communication device to the interface server. The method can also include routing a termination communication intended for the mobile communication device from the mobile switching center to the interface server according to the routing association, and routing the termination communication from the interface server to the mobile communication device over the communication path. Registering the mobile communication device with the nomadic server can provide a connectivity status of the mobile communication device while the mobile communication device is within a specific coverage area of a specific WiFi access point.

In yet another aspect of the present invention, a system provides communications for a mobile communication device that roams between multiple different types of wireless networks. The system includes a plurality of different types of wireless networks, the mobile communication device configured to access the plurality of wireless networks, and an interface server coupled to the plurality of wireless networks, wherein the interface server maintains a seamless communication link between the mobile communication device and an end destination device as the mobile communication device roams from a first wireless coverage area associated within a first type of wireless network to a second wireless coverage area associated with a second type of wireless network, the interface server is configured to establish a second communication link over the second type of wireless network while a first communication link between the mobile communication device and the end destination device over the first type of wireless network is active, wherein the second communication link is initially set up to be forwarded to the interface server and subsequently the second communication link is routed to the mobile communication device as the first communication link is terminated. The first communication link can include a first wireless communication link between the mobile communication device and the first type of wireless network. The first wireless coverage area can be a WiFi coverage area, and the first wireless communication link can be a WiFi communication link between the mobile communication device and a WiFi access point. The first communication link can include a routing path through a VOIP network. The first communication link can include a routing path through a cellular network. The second communication link can include a second wireless communication link between the mobile communication device and the second type of wireless network. The second wireless coverage area can be a cellular coverage area and the second wireless communication link can be a wireless cellular communication link between the mobile communication device and a cellular base station. The second communication link can include a routing path through a VOIP network. The second communication link can include a routing path through a cellular network. The second type of wireless network can include a wireless cellular network.

In still yet another aspect of the present invention, an interface server maintains a seamless communication link between a mobile communication device and an end destination device as the mobile communication device roams from a first wireless coverage area associated within a first type of wireless network to a second wireless coverage area associated with a second type of wireless network, the interface server is configured to establish a second communication link over the second type of wireless network while a first communication link between the mobile communication device and the end destination device over the first type of wireless network is active, wherein the second communication link is initially set up to be forwarded to the interface server and subsequently the second communication link is routed to the mobile communication device as the first communication link is terminated. The interface server can also include a first inter-network function block to maintain current configuration and status information associated with the first communication link. The first wireless coverage area can be a WiFi coverage area, and the first communication link can be a WiFi communication link between the mobile communication device and a WiFi access point. The interface server can also include a second inter-network function block to maintain current configuration and status information associated with the second communication link. The interface server can also include a provisioning server to provide the mobile communication device with configuration information.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** illustrates an exemplary system of interconnected networks in which a nomadic server is coupled to a cellular network, a wireless IP network, and a public switched telephone network.

FIG. **2** illustrates a simplified high-level block diagram of one embodiment of the mobile communication device.

FIG. **3** illustrates a method of providing communications for a mobile communication device that roams between multiple WiFi coverage areas according to some embodiments.

FIG. **4** illustrates a method of providing communications between mobile communication devices according to some embodiments.

The present invention is described relative to the several views of the drawings. Where appropriate and only where identical elements are disclosed and shown in more than one drawing, the same reference numeral will be used to represent such identical elements.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of a nomadic server enable telephone communications that can be initiated using VOIP while within a VOIP access point, such as a WiFi hotspot, and enable telephone communications that can be initiated using a cellular network while within a cellular area and outside of a VOIP access point. When a caller roams outside the range of a VOIP access point, the nomadic server functions to "hold" the current telephone communication while switching occurs from the VOIP access point to the cellular network. Similarly, when a caller roams into the range of a VOIP access point while engaged in a telephone communication on the cellular network, the nomadic server functions to "hold" the current telephone communication while switching occurs from the cellular network to the VOIP access point. The nomadic server remains engaged, or active, in the telephone communication while switching from one network to another. After switching is completed, the nomadic server disengages from the telephone communication.

FIG. **1** illustrates an exemplary system of interconnected networks in which a nomadic server **80** is coupled to a cellular network, a wireless IP network, and a public switched telephone network (PSTN) **60**. The cellular network shown in FIG. **1** includes a mobile switching center **20** coupled to a public land mobile network **30**, and a plurality of base stations **10** coupled to the mobile switching center **20**. For clarity, the cellular network shown in FIG. **1** is a simplified cellular network architecture. For example, the cellular network in FIG. **1** includes only a single mobile switching center, however it is understood that the cellular network includes multiple mobile switching centers. Further, it will be apparent to those skilled in the art, that the functionality of the mobile switching center could alternatively be incorporated into either the base station or any other cellular network infrastructure, or into the nomadic server. Accordingly, as used herein, the term mobile switching center refers to the mobile switching center or any appropriate device within the cellular network equipment infrastructure which performs the functionality of a mobile switching center. FIG. **1** shows four base stations **10** coupled to the mobile switching center **20**. Alternatively, more or less than four base stations can be coupled to each mobile switching center.

The wireless IP network shown in FIG. **1** includes a plurality of wireless IP access points **40** coupled to the Internet **50**. Examples of a wireless IP access point include, but are not limited to, a wireless or wired broadband termination element, a wireless or wired modem, a wireless or wired router, and a WiFi access point.

In this example, the nomadic server **80** is coupled to the PSTN **60** through the softswitch **70**. The softswitch **70** provides an interface for the nomadic server **80** to legacy networks, such as the PSTN.

A mobile communication device **90** is preferably a dual mode telephone that provides VoIP client functionality over a WiFi network and GSM/CDMA mobile telephony functionality over a cellular network. The mobile communication device **90** can also be configured to automatically switch an existing communication from a cellular network to a wireless IP network, or to switch an existing communication from an IP network to a cellular network. Such a mobile communication device is described in co-pending and co-owned U.S. patent application Ser. No. 11/031,498, filed Jan. 6, 2005, and entitled "TELEPHONE WITH AUTOMATIC SWITCHING BETWEEN CELLULAR AND VOIP NETWORKS", which is hereby incorporated by reference. Alternative types of mobile communication devices include, but are not limited to, laptop computers, music players/recorders, PDAs, telephones, or any conventional mobile communication device capable of receiving broadband content over a wireless connection.

FIG. **2** illustrates a simplified high-level block diagram of one embodiment of the mobile communication device **90**. The mobile communication device **90** includes a WiFi portion and a cellular portion. The cellular part uses either GSM or CDMA, and access to a communications network is provided through the nearest base station **10**. The WiFi portion uses the VOIP client to originate and terminate communications over the WiFi network. The mobile communication device **90** is adapted to automatically switch communications between cellular and VOIP networks. The mobile communication device **90** includes a cellular communication module **93** coupled to a cellular antenna **91**, a WiFi communication module **94** coupled to a WiFi antenna **92**, an audio/video amplifier **95**, a network switch unit **96**, a timer unit **97**, a WiFi signal level strength monitor **98**, a microphone **100**, a speaker **99**, and a display monitor **101**. The mobile communication device **90** is adapted to establish and maintain communication via either the cellular communication module **93** coupled to a cellular base station **10** (FIG. **1**), and/or via the WiFi communication module **94** coupled to a WiFi access point **40** (FIG. **1**). The cellular communication module **93** further includes a transceiver **102** adapted to transmit signals to and receive signals from a cellular network. The WiFi communication module **94** further includes a transceiver **103** adapted to transmit signals to and receive signals from an IP network. Depending on the level of the detected WiFi signal emitted from a WiFi access point, a call initially established via cellular communication module **93** can be switched to be handled by the WiFi communication module **94**, or a call initially established via the WiFi communication module **94** can be switched to be handled by the cellular communication module **93**.

Referring back to FIG. **1**, the nomadic server **80** enables a seamless handoff from one wireless access point to another as the mobile telephone device **90** roams from one WiFi coverage area to another WiFi coverage area, or roams outside a WiFi coverage area but still within a cellular network coverage area. The nomadic server **80** includes a cellular inter-working function (CIWF) block **82**, a WiFi inter-working function (WIWF) block **84**, and a provisioning server **86**. The nomadic server **80** and the mobile switching center **20** are either “tightly” coupled or “loosely” coupled. When tightly coupled, the nomadic server **80** and the mobile switching center **20** are coupled together by a local area network (LAN), or a wide area network (WAN) or any other appropriate interface, using either a proprietary or non-proprietary interface of the mobile switching center **20**. In this manner, the nomadic server **80** is able to communicate to the mobile switching center **20** through this interface. When loosely coupled, the nomadic server **80** and the mobile switching center **20** are coupled using an Integrated Services Digital Network (ISDNC) trunk, or by using a softswitch or any other appropriate interface. In this context, a softswitch is defined variously as a media gateway controller, call agent or gate keeper, used to control connections at the junction point between circuit and packet networks.

The nomadic server **80** is coupled to one or more mobile switching centers **20** for communicating signaling and media traffic. A point of interconnection (PoI), is formed between each mobile switching center **20** and the nomadic server **80**. Within any given network, one or more nomadic servers **80** can be implemented. Each mobile communication device **90** is associated with a home nomadic server, in this case the nomadic server **80**. Each nomadic server can be the home nomadic server for one or more mobile communication devices. Preferably, a mobile switching center is interfaced to only one nomadic server such that a home mobile switching center is interfaced to the home nomadic server. In this manner, the mobile communication device is associated with a home mobile switching center. Alternatively, multiple mobile switching centers are coupled to any given nomadic server.

When the mobile communication device **90** originates a call within a WiFi coverage area, a WiFi communication link is established with the nomadic server **80**. The call can be completed by the nomadic server **80** over the cellular network or the VOIP network. If the call is completed over the cellular network, then the call is routed through any mobile switching center coupled to the nomadic server **80**. If the call is completed over the VOIP network, then the call is routed through a softswitch **70** of a service provider, using the Session Initiation Protocol (SIP) or any other appropriate protocols, such as H323. In other words, if the mobile communication device **90** is located within a WiFi coverage area, then the first leg of the call is routed over a WiFi communication link and the remaining portion of the call can be routed over either the cellular network, the VOIP network, or the PSTN.

In operation, a first call is established by the mobile communication device **90** by first determining if it is in a WiFi coverage area. Such a determination is preferably made by measuring a signal strength or other criteria of the nearest WiFi access point **40**, and if the signal strength or other criteria is above a predetermined threshold, then a WiFi communication link is established. If WiFi access is not available, then the mobile communication device **90** establishes a cellular communication link with the nearest base station **10**. When the mobile communication device **90** first establishes a WiFi communication link, the mobile communication device **90** establishes a communication link with the provisioning server **86** over the WiFi communication link. The WiFi communication link includes the WiFi access point **40**, and the Internet **50**. The provisioning server **86** provides the mobile communication device **90** with configuration information including an identification of its home nomadic server, which in this case is the nomadic server **80**. The mobile communication device **90** preferably uses XML over SSL for communicating with the provisioning server **86** over the Internet **50**.

The mobile communication device **90** also registers with the nomadic server **80**. In some embodiments, a SIP REGISTER method or any other appropriate protocol, such as H323, with authentication is used between the mobile communication device **90** and the nomadic server **80**. The nomadic server **80** also maintains configuration information of the mobile switching center **20**. The nomadic server **80** updates the mobile switching center **20** with a current location of the mobile communication device **90**. The current location refers to the WiFi access point associated with the WiFi coverage area in which the mobile communication device **90** is currently located. The nomadic server **80** updates the mobile switching center **20** with the location of the mobile communication device **90** at a specified periodicity. In this manner, the mobile switching center **20** maintains a current location of the mobile communication device **90**. Using this location information, calls received over the cellular network for the mobile communication device **90** are directed from the mobile switching center **20** over the WiFi communication link via the nomadic server **80**.

As long as the mobile communication device **90** maintains a WiFi communication link with the wireless access point **40**, irrespective of the cellular network coverage, the mobile communication device **90** registers with its home nomadic server, the nomadic server **80** in this case. The nomadic server **80** in turn updates the current location of the mobile communication device **90** in the mobile switching center **20**. When a signal strength or other criteria of the WiFi communication link weakens below a predetermined threshold, the mobile communication device **90** notifies the nomadic server **80**. In response, the nomadic server **80** stops sending location updates to the mobile switching center **20**. Additionally, the mobile communication device **90** stops sending SIP registrations to the nomadic server **80**, and the mobile communication device **90** initiates registration with the nearest mobile switching center. In this manner, subsequent calls originating from or terminating at the mobile communication device **90** are handled by the mobile switching center. The nearest mobile switching center can be the home mobile switching center of the mobile communication device **90** or another mobile switching center, referred to as a visitor mobile switching center, within the cellular network.

While the first call is still established over the WiFi communication link, the mobile communication device **90** sets up a second call to the same end destination as the first call currently setup over the WiFi communication link, thereby establishing a cellular communication link. If the cellular communication link is established via the home mobile switching center, then the second call is routed to the nomadic server **80** via the PoI between the home mobile switching center and the nomadic server **80**. In response, the nomadic server **80** determines if the first call over the WiFi communication link is still in progress. If so, access is switched from the WiFi communication link to the cellular communication link.

If, however, the cellular communication link is established over a visitor mobile switching center, then the visitor mobile switching center forwards the second call to a visitor nomadic server coupled to the visitor mobile switching center. The visitor nomadic server can not determine the status of the first call over the WiFi communication link, so the visitor nomadic server switches the second call to the end destination. Concurrently, the home nomadic server, which previously received the notification from the mobile communication device **90** about losing the WiFi communication link, waits for a connection request from the home mobile switching center for the second call to be established. However, the home nomadic server will not receive such a connection request since the second call is being processed by the visitor nomadic server. As such, the home nomadic server drops the first call on the WiFi communication link, and the second call is maintained by the mobile communication device **90** over the cellular communication link.

Once a cellular communication link is established between the mobile communication device **90** and the nearest mobile switching center, the mobile communication device **90** does not attempt to establish another WiFi communication link upon re-entering a WiFi coverage area. The mobile communication device **90** attempts access to a WiFi communication link when the mobile communication device **90** is back in an idle state.

As the mobile communication device roams from a first coverage area to a second coverage area, the transition steps vary depending on the type of the second coverage area and on the original call setup configuration. Roaming from the first coverage area to the second coverage area can generally be accomplished according to one of five different scenarios, each scenario including associated transition steps.

A first scenario includes the mobile communication device roaming from a first WiFi coverage area to a second WiFi coverage area. The first WiFi coverage area is associated with a first WiFi access point, and the second WiFi coverage area is associated with a second WiFi access point. Each WiFi access point includes an IP address. When the mobile communication device is within the first WiFi coverage area, the mobile communication device registers with its home nomadic server over the first WiFi access point. The home nomadic server updates the location of the mobile communication device with the home mobile switching center of the mobile communication device. For incoming calls directed to the mobile communication device, the home mobile switching center routes the calls to the home nomadic server based on the most recent location information.

When the mobile communication device roams into the second WiFi coverage area, the mobile communication device detects the transition. The mobile communication device acquires the IP address from the second WiFi access point and sends the IP address change to the provisioning server of the home nomadic server. The mobile communication device also sends a SIP register message with the new IP address to the home nomadic server. In response, the home nomadic server redirects any incoming calls to the IP address of the second WiFi access point. The location of the mobile communication device maintained by the home mobile switching center is still valid.

A second scenario includes the mobile communication device **90** initiating a call within a first WiFi coverage area, setting up the call over a VOIP network, and roaming from the first WiFi coverage area to a cellular coverage area supported by the home mobile switching center of the mobile communication device **90**. In this scenario, the mobile communication device **90** roams from the first WiFi coverage area to a non-WiFi coverage area. When a first call is initiated and setup, a WiFi communication link is established between the mobile communication device and a first wireless access point associated with the first WiFi coverage area. When the mobile communication device is within the first WiFi coverage area, the mobile communication device registers with its home nomadic server via the first WiFi access point. The first call is routed from the first wireless access point through a VOIP network, such as the Internet.

The mobile communication device monitors a signal strength or other criteria of the WiFi communication link. When the signal strength or other criteria drops below a predetermined threshold, the mobile communication device registers with the nearest mobile switching center, which in this second scenario is the home mobile switching center of the mobile communication device. The mobile communication device also sends a call setup request to the home mobile switching center for a second call with the same end destination as the first call. The second call is setup by the home mobile switching center, and the second call is routed to the CIWF block within the home nomadic server. The CIWF block determines from the WIWF block if the first call is in progress. If the first call is in progress, then the CIWF block sends an affirmative answer message to the home mobile switching center. The home mobile switching center in turn sends the affirmative answer message to the mobile communication device.

In response to receiving the affirmative answer message, the mobile communication device stops media streaming over the WiFi communication link and powers down the WiFi part. The CIWF block then changes the registration of the mobile communication device in the WIWF block with an IP address of the CIWF block. The CIWF block sends a re-invite message to the WIWF block signifying a media switchover to the IP address of the CIWF block from the IP address of the first wireless access point. Media streaming associated with the first call is then redirected to the CIWF block, where the media is then switched over to the home mobile switching center. Media associated with the first call is now associated with the second call, where the media is now streamed from the VOIP network to the WIWF block to the CIWF block to the home mobile switching center to the mobile communication device. The transition according to the second scenario is now complete. If the second call is subsequently disconnected by the mobile communication device, then the corresponding call breakdown process is supervised by the CIWF block. If the second call is subsequently disconnected by the end destination device, then the corresponding call breakdown process is supervised by both the WIWF block and the CIWF block.

A third scenario includes the mobile communication device initiating a call within a first WiFi coverage area, setting up a back end of the call over a cellular network, and roaming from the first WiFi coverage area to a cellular coverage area supported by the home mobile switching center of the mobile communication device. In this scenario, the mobile communication device roams from the first WiFi coverage area to a non-WiFi coverage area. When a first call is initiated and setup, a WiFi communication link is established between the mobile communication device and a first wireless access point associated with the first WiFi coverage area. When the mobile communication device is within the first WiFi coverage area, the mobile communication device registers with its home nomadic server via the first WiFi access point. The first call is routed from the wireless access point **40** through a cellular network, such as the mobile switching center and either the PLMN or the PSTN.

The mobile communication device monitors a signal strength or other criteria of the WiFi communication link. When the signal strength or other criteria drops below a predetermined threshold, the mobile communication device registers with the nearest mobile switching center, which in this third scenario is the home mobile switching center of the mobile communication device. The mobile communication device also sends a call setup request to the home mobile switching center for a second call with the same end destination as the first call. The second call is setup by the home mobile switching center, and the second call is routed to the CIWF block within the home nomadic server. The CIWF block determines from the WIWF block if the first call is in progress. If the first call is in progress, then the CIWF block sends an affirmative answer message to the home mobile switching center. The home mobile switching center in turn sends the affirmative answer message to the mobile communication device.

In response to receiving the affirmative answer message, the mobile communication device stops media streaming over the WiFi communication link and powers down its WiFi part. The CIWF block then changes the registration of the mobile communication device in the WIWF block with an IP address of the CIWF block. The CIWF block sends a re-invite message to the WIWF block signifying a media switchover to the IP address of the CIWF block from the IP address of the first wireless access point. Media streaming associated with the first call is then redirected to the CIWF block, where the media is then switched over to the home mobile switching center. The media stream associated with the first call is now associated with the second call, where the media stream is now directed from the cellular network to the CIWF block to the home mobile switching center to the mobile communication device. The transition according to the third scenario is now complete. If the second call is subsequently disconnected by the mobile communication device, then the corresponding call breakdown process is supervised by the CIWF block and the home mobile switching center. If the second call is subsequently disconnected by the end destination device, then the corresponding call breakdown process is supervised by the CIWF block.

A fourth scenario includes the mobile communication device initiating a call within a first WiFi coverage area that resides outside a cellular coverage area supported by the home mobile switching center of the mobile communication device, setting up a back end of the call over a VOIP network, and roaming from the first WiFi coverage area to a cellular coverage area supported by a visitor mobile switching center. In this scenario, the mobile communication device roams from the first WiFi coverage area to a non-WiFi coverage area. When a first call is initiated and setup, a WiFi communication link is established between the mobile communication device and a first wireless access point associated with the first WiFi coverage area. When the mobile communication device is within the first WiFi coverage area, the mobile communication device registers with its home nomadic server via the first WiFi access point. In this manner, the WIWF block in the home nomadic server monitors the location of the mobile communication device. The first call is routed from the mobile communication device to the first wireless access point via the WiFi communication link to the WIWF block of the visitor nomadic server associated with the visitor mobile switching center to the VOIP network

The mobile communication device monitors a signal strength or other criteria of the WiFi communication link. When the signal strength or other criteria drops below a predetermined threshold, the mobile communication device registers with the nearest mobile switching center, which in this fourth scenario is the visitor mobile switching center. The mobile communication device notifies the WIWF block in its home nomadic server that the signal strength or other criteria is below the predetermined threshold. The mobile communication device also sends a call setup request to the visitor mobile switching center for a second call with the same end destination as the first call. The visitor mobile switching center forwards the call setup request to the CIWF block within the visitor nomadic server. Within the visitor nomadic server, the CIWF block determines from the WIWF block if the first call is in progress. Since the mobile communication device has been registering itself with its home nomadic server, and not with the visitor nomadic server, the WIWF block within the visitor nomadic server does not have a record of the first call being in progress. In response, the visitor nomadic server sets up the second call over the cellular network. Concurrently, the home nomadic server tears down the first call over the VOIP network.

A fifth scenario includes the mobile communication device initiating a call within a first WiFi coverage area that resides outside a cellular coverage area supported by the home mobile switching center of the mobile communication device, setting up a back end of the call over a cellular network, and roaming from the first WiFi coverage area to a cellular coverage area supported by a visitor mobile switching center. In this scenario, the mobile communication device roams from the first WiFi coverage area to a non-WiFi coverage area. When a first call is initiated and setup, a WiFi communication link is established between the mobile communication device and a first wireless access point associated with the first WiFi access point. The first call is routed from the mobile communication device to the first wireless access point via the WiFi communication link to the CIWF block of the visitor nomadic server to the visitor mobile switching center to the cellular network.

The mobile communication device monitors a signal strength or other criteria of the WiFi communication link. When the signal strength or other criteria drops below a predetermined threshold, the mobile communication device registers with the nearest mobile switching center, which in this fifth scenario is the visitor mobile switching center. When the mobile communication device is within the first WiFi coverage area, the mobile communication device registers with its home nomadic server via the first WiFi access point. In this manner, the WIWF block in the home nomadic server monitors the location of the mobile communication device. The mobile communication device notifies the WIWF block in its home nomadic server that the signal strength or other criteria is below the predetermined threshold. The mobile communication device also sends a call setup request to the visitor mobile switching center for a second call with the same end destination as the first call. The visitor mobile switching center forwards the call setup request to the CIWF block within the visitor nomadic server. Within the visitor nomadic server, the CIWF block determines from the WIWF block if the first call is in progress. Since the mobile communication device has been registering itself with its home nomadic server, and not with the visitor nomadic server, the WIWF block within the visitor nomadic server does not have a record of the first call being in progress. In response, the visitor nomadic server sets up the second call over the cellular network. Concurrently, the home nomadic server tears down the first call over the cellular network and the first WiFi communication link.

It is understood that the five scenarios described above are not exhaustive or inclusive of all scenarios in which the mobile communication device can roam from a first coverage area to a second coverage area with the support of the nomadic server. It is understood that other scenarios are also contemplated.

In some embodiments, the nomadic server **80** also communicates to other nomadic services over the Internet to route and complete calls using VOIP. This server-to-server communication can be used for all calls, even for cellular to cellular calls. In such a situation, the cellular telephone communication is transmitted from the initiating cellular telephone to the appropriate base station. From this base station, the communication is routed to the appropriate nomadic server **80**, which in some embodiments is the nomadic server **80** that is the closest to the receiving base station **10**. This initiating nomadic server **80** then transmits the communication over the Internet, to the nomadic server **80** that is closest to the appropriate base station **10** corresponding to the location of the receiver's cellular telephone. This receiving nomadic server **80** then transmits the communication to this receiving base station **10**, which transmits the communication to the receiver's cellular telephone. In this manner, the only portions of the transmission that are communicated over the cellular telephone network, are the initial leg, from the initiating cellular telephone to the appropriate base station, and the final leg, from the appropriate base station to the receiver's cellular telephone. The remaining, intermediate, portions of the transmission are communicated between the appropriate nomadic servers over the Internet, which allows the call to be completed more efficiently than if the call was transmitted completely over the cellular network in the traditional manner. As will be apparent to those skilled in the art, communications are directed in both directions in this manner in order to complete the call between the initiator and the receiver, with the initial and final portions of the transmission routed over the cellular network and the remaining intermediate portions of the transmission routed between nomadic servers **80**, over the Internet **50**.

FIG. **3** illustrates a method of providing communications for a mobile communication device that roams between multiple WiFi coverage areas according to some embodiments. As shown in FIG. **3**, the mobile communication device is associated with a nomadic server, wherein the nomadic server is coupled to one or more WiFi access points at the step **302**. A first WiFi communication link is established between the mobile communication device and a first WiFi access point at the step **304**. The mobile communication device is registered with the nomadic server including providing an IP address of the first WiFi access point to the nomadic server at the step **306**. A communication path to the mobile communication device is configured via the nomadic server according to the IP address of the first WiFi access point and the first WiFi communication link at the step **308**. Movement of the mobile communication device into a coverage area of a second WiFi access point is detected at the step **310**. The mobile communication device is registered with the nomadic server including an IP address of the second WiFi access point at the step **312**. A second WiFi communication link is established between the mobile communication device and the second WiFi access point at the step **314**. The communication path is re-configured according to the IP address of the second WiFi access point and the second WiFi communication link at the step **316**. The mobile communication device notifies the nomadic server if the first communication link falls below a threshold at the step **318**. The mobile communication device is associated with the nomadic server at the mobile switching center at the step **320**. A routing association is provided to a mobile switching center within a cellular network, wherein the routing association associates the mobile communication device to the interface server at the step **322**. A termination communication intended for the mobile communication device from the mobile switching center is routed to the interface server according to the routing association, and routing the termination communication from the interface server to the mobile communication device over the communication path at the step **324**. Providing a connectivity status of the mobile communication device while the mobile communication device is within a specific coverage area of a specific WiFi access point by registering the mobile communication device with the nomadic server at the step **326**.

FIG. **4** illustrates a method of providing communications between mobile communication devices according to some embodiments. As shown in FIG. **4**, a communication is routed over a first communication link between a first mobile communication device and a first cellular base station, wherein the communication is directed from the first mobile communication device to a second communication device at the step **402**. The communication is routed over a second communication link between the first cellular base station and a first controller device at the step **404**. The communication is routed over a third communication link between the first controller device and a second controller device, wherein the third communication link comprises a Internet Protocol network at the step **406**. The communication is routed over a fourth communication link between the second controller device and a second cellular base station at the step **408**. The communication is routed over a fifth communication link between the second cellular base station and the second communication device at the step **410**. The mobile communication device notifies an interface server if the first communication link falls below a threshold at the step **412**.

The present invention has been described in terms of specific embodiments incorporating details to facilitate the understanding of the principles of construction and operation of the invention. As such, references herein to specific embodiments and details thereof are not intended to limit the scope of the claims appended hereto. It will be apparent to those skilled in the art that modifications can be made to the embodiments chosen for illustration without departing from the spirit and scope of the invention.

I claim:

1. A method of providing communications for a mobile communication device that roams between multiple different types of wireless networks, the method comprising:

establishing a first communication link between the mobile communication device and an end destination device, wherein the first communication link includes a first wireless communication link between the mobile communication device and a first type of wireless network;

monitoring a signal strength of the first wireless communication link;

when the signal strength drops below a predetermined threshold, notifying an interface server with the mobile communication device and establishing a second communication link between the interface server and the end destination device without disrupting the first communication link;

notifying the mobile communication device to terminate transmission over the first communication link; and

re-directing the second communication link from the interface server to the mobile communication device, thereby establishing a second wireless communication link between the mobile communication device and the second type of wireless network.

2. The method of claim **1** wherein the first type of wireless communication link comprises a IEEE 802.11 standard based communication link, and the first type of wireless network includes a IEEE 802.11 standard based network access point.

3. The method of claim **2** wherein the second type of wireless network includes a wireless cellular network.

4. The method of claim **1** wherein establishing the first communication link includes routing through a voice over internet protocol network.

5. The method of claim **1** wherein establishing the first communication link includes routing through a cellular network.

6. The method of claim **1** wherein establishing the second communication link includes routing through a voice over internet protocol network.

7. The method of claim **1** wherein establishing the second communication link includes routing through a cellular network.

8. The method of claim **1** further comprising providing a connectivity status by the mobile communication device to the interface server while the mobile communication device is within a first coverage area of the first type of wireless network.

9. The method of claim **8** further comprising providing a routing association to a mobile switching center within the second type of wireless network, wherein the routing association associates the mobile communication device to the interface server.

10. The method of claim **9** further comprising routing a termination communication intended for the mobile communication device from the mobile switching center to the interface server according to the routing association when the connectivity status is active, and routing the termination communication from the interface server to the mobile communication device over the first type of wireless network.

11. The method of claim **10** further comprising when the connectivity status is not provided to the interface server, the routing association is removed from the mobile switching center.

12. The method of claim **1** further comprising registering the mobile communication device with a mobile switching center within the second type of wireless network when the signal strength drops below the predetermined threshold.

13. The method of claim **12** further comprising setting up the second communication link with the end destination device and forwarding the second communication link to the interface server.

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