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(54) **SYSTEM AND METHOD FOR MANAGING BASE STATIONS IN A WIRELESS SYSTEM**

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(51) **Int. Cl.**[7] **H04Q 7/20**

(52) **U.S. Cl.** **455/561**; 455/466

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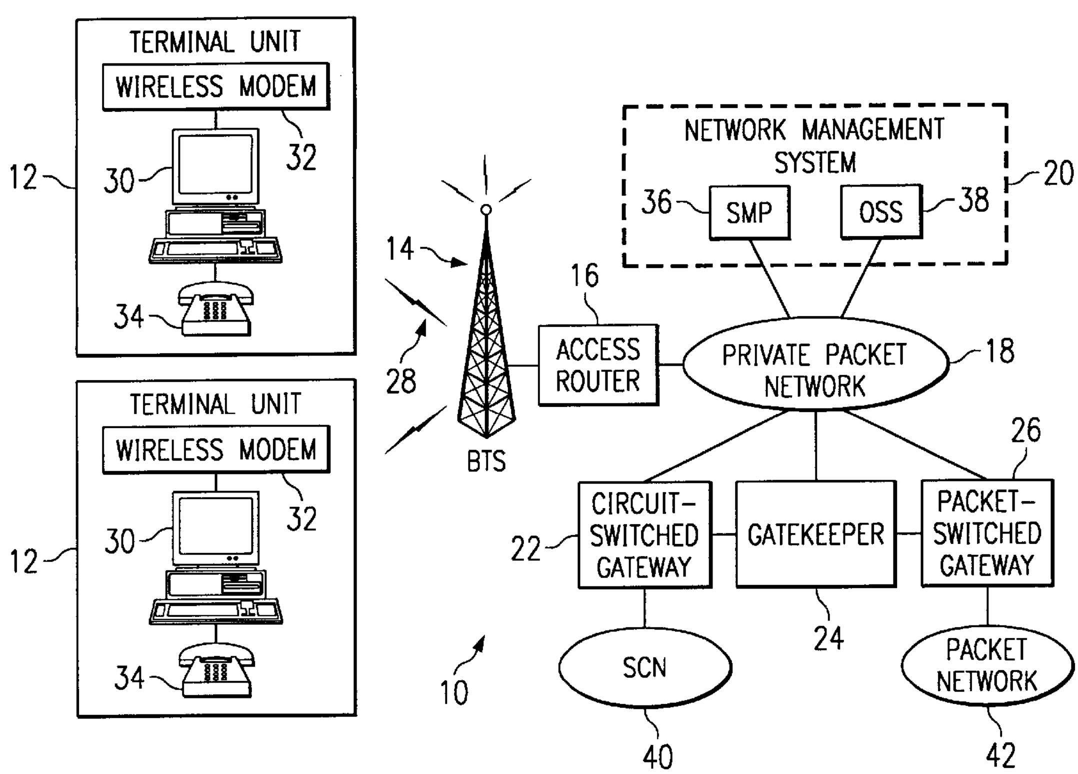
Primary Examiner—Daniel T. Pihulic

(57) **ABSTRACT**

A communications system includes a base station operable to communicate with a terminal unit over a wireless interface and a packet network coupled to the base station and operable to communicate with the base station. The communications system also includes a network management system coupled to the packet network. The network management system is operable to generate a management message to manage the base station. The network management system is also operable to transparently communicate the management message to the base station and to transparently receive a response to the management message from the base station.

20 Claims, 4 Drawing Sheets



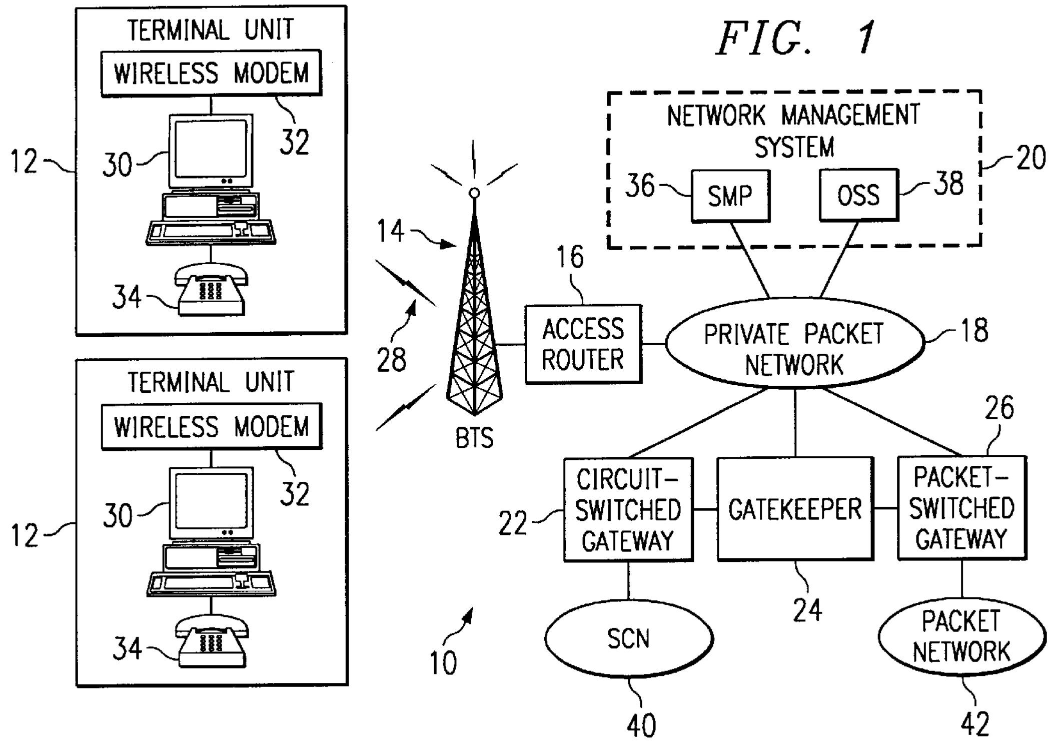

TERMINAL UNIT
WIRELESS MODEM
12
30
32
34
TERMINAL UNIT
WIRELESS MODEM
12
30
32
34
14
28
BTS
16
ACCESS ROUTER
NETWORK MANAGEMENT SYSTEM
36
SMP
OSS
38
20
PRIVATE PACKET NETWORK
18
26
CIRCUIT-SWITCHED GATEWAY
GATEKEEPER
PACKET-SWITCHED GATEWAY
22
24
SCN
PACKET NETWORK
10
40
42

FIG. 1

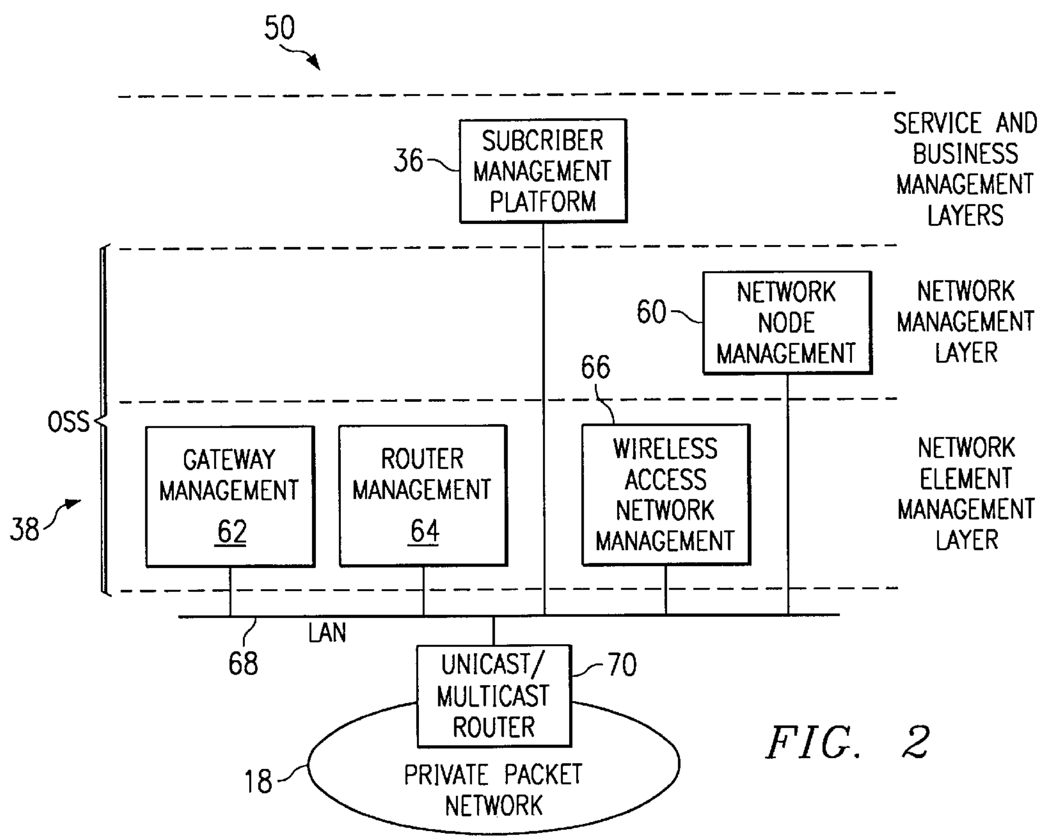

50
36
SUBCRIBER MANAGEMENT PLATFORM
SERVICE AND BUSINESS MANAGEMENT LAYERS
60
NETWORK NODE MANAGEMENT
NETWORK MANAGEMENT LAYER
66
OSS
GATEWAY MANAGEMENT 62
ROUTER MANAGEMENT 64
WIRELESS ACCESS NETWORK MANAGEMENT
NETWORK ELEMENT MANAGEMENT LAYER
38
LAN
68
UNICAST/ MULTICAST ROUTER
70
18
PRIVATE PACKET NETWORK

FIG. 2

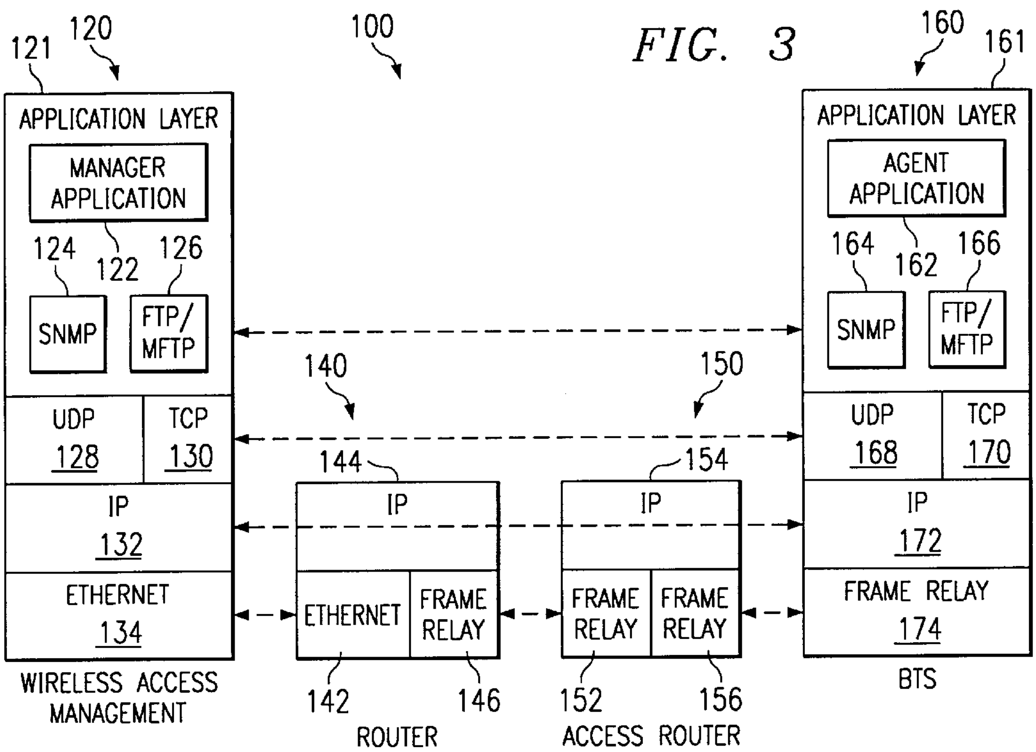


FIG. 3

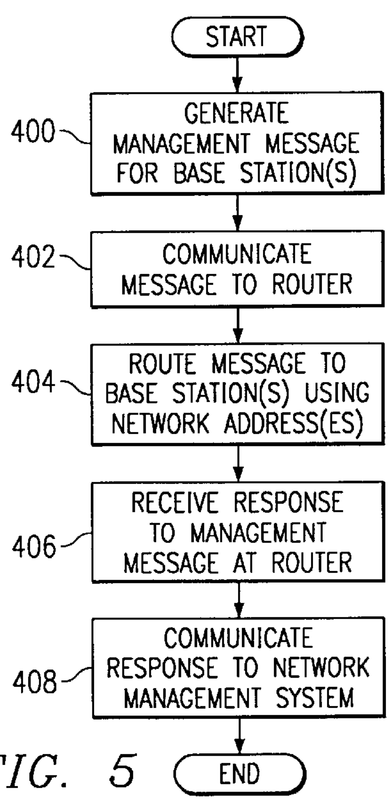


FIG. 5

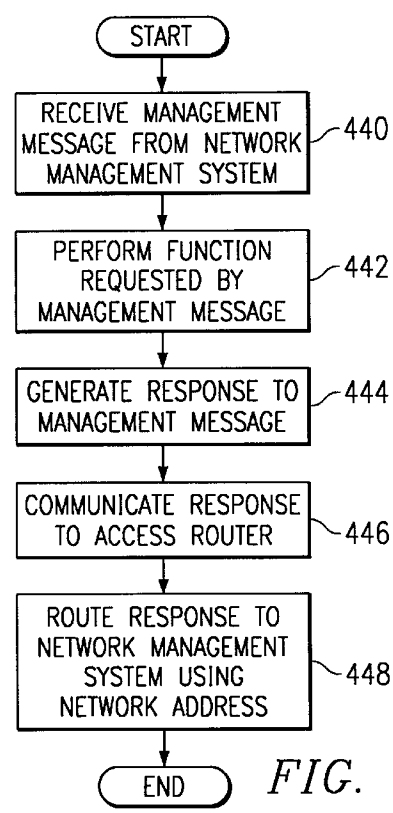


FIG. 6

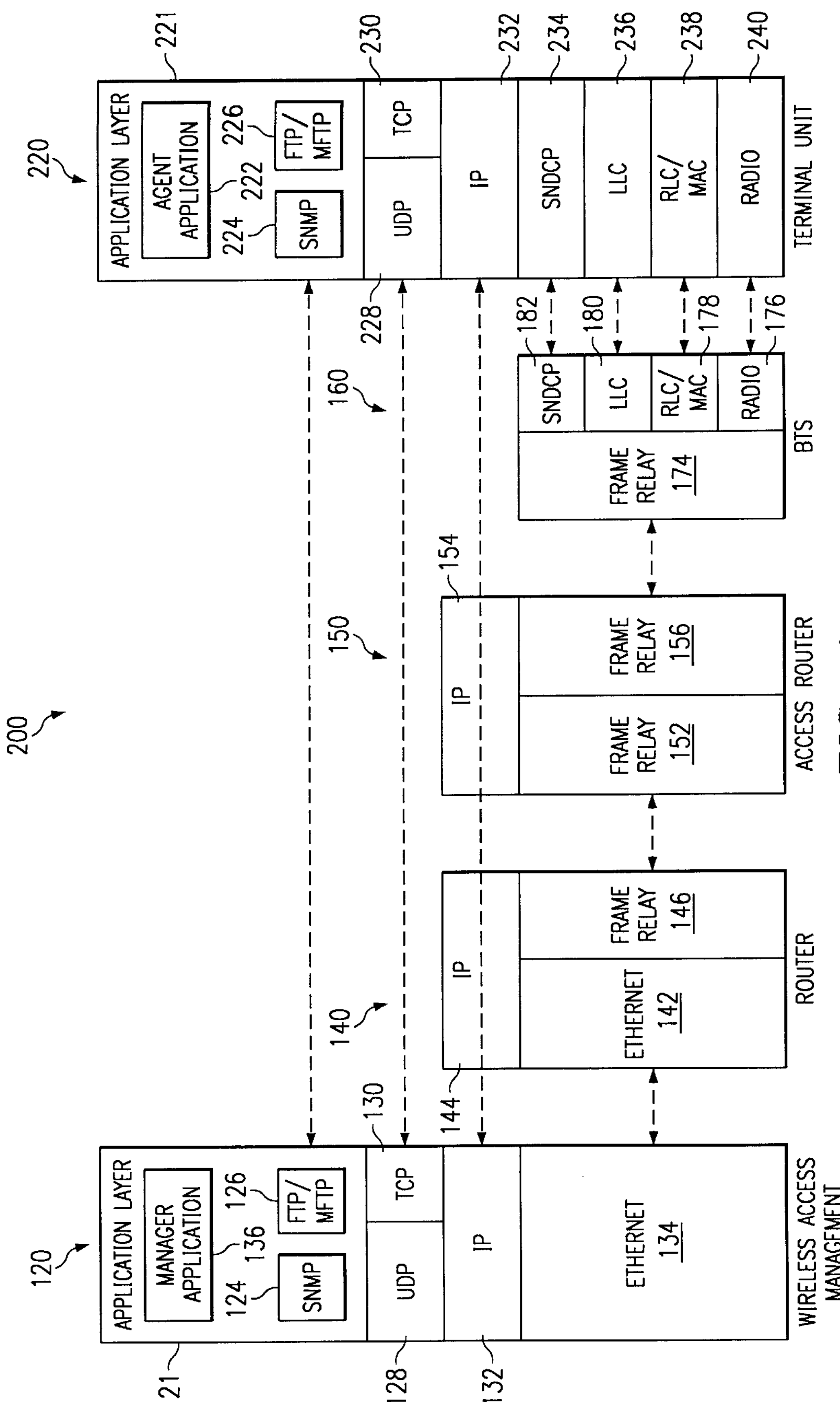

200
220
221
APPLICATION LAYER
AGENT APPLICATION
222
224
SNMP
226
FTP/ MFTP
230
TCP
228
UDP
232
IP
234
SNDCP
236
LLC
238
RLC/ MAC
240
RADIO
TERMINAL UNIT
160
182
SNDCP
180
LLC
178
RLC/ MAC
176
RADIO
FRAME RELAY 174
BTS
150
154
IP
FRAME RELAY 156
FRAME RELAY 152
ACCESS ROUTER
140
IP
FRAME RELAY 146
ETHERNET 142
144
ROUTER
120
121
APPLICATION LAYER
MANAGER APPLICATION
136
124
SNMP
126
FTP/ MFTP
130
TCP
128
UDP
132
IP
ETHERNET 134
WIRELESS ACCESS MANAGEMENT

FIG. 4

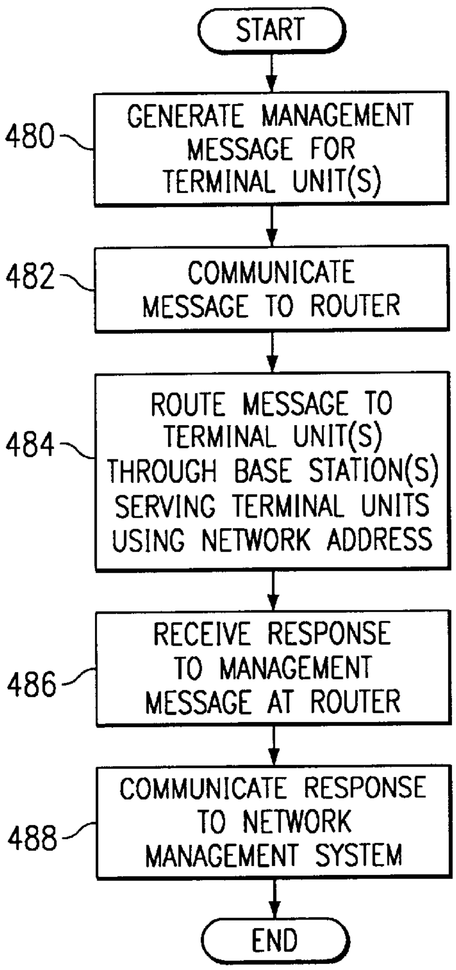

START
480
GENERATE MANAGEMENT MESSAGE FOR TERMINAL UNIT(S)
482
COMMUNICATE MESSAGE TO ROUTER
484
ROUTE MESSAGE TO TERMINAL UNIT(S) THROUGH BASE STATION(S) SERVING TERMINAL UNITS USING NETWORK ADDRESS
486
RECEIVE RESPONSE TO MANAGEMENT MESSAGE AT ROUTER
488
COMMUNICATE RESPONSE TO NETWORK MANAGEMENT SYSTEM
END

FIG. 7

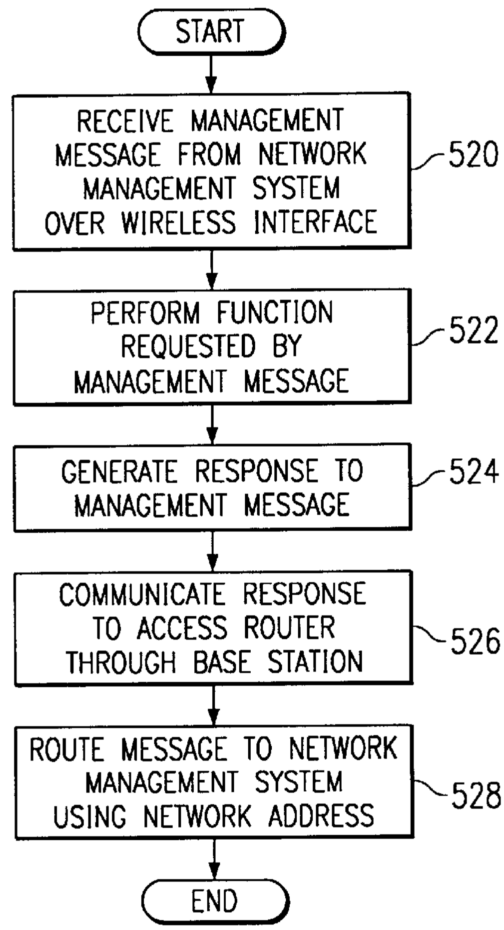

START
RECEIVE MANAGEMENT MESSAGE FROM NETWORK MANAGEMENT SYSTEM OVER WIRELESS INTERFACE
520
PERFORM FUNCTION REQUESTED BY MANAGEMENT MESSAGE
522
GENERATE RESPONSE TO MANAGEMENT MESSAGE
524
COMMUNICATE RESPONSE TO ACCESS ROUTER THROUGH BASE STATION
526
ROUTE MESSAGE TO NETWORK MANAGEMENT SYSTEM USING NETWORK ADDRESS
528
END

FIG. 8

SYSTEM AND METHOD FOR MANAGING BASE STATIONS IN A WIRELESS SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the following applications:

U.S. application Ser. No. 09/128,553, filed on Aug. 3, 1998, by Lynn McKernan and entitled "A 'Plug and Play' Wireless Architecture Supporting Packet Data and IP Voice/Multimedia Services," now abandoned;

U.S. application Ser. No. 09/219,539 filed on Dec. 23, 1998, by Lynn McKeman and entitled "Wireless Local Loop System Supporting Voice/IP," now abandoned; and

U.S. application Ser. No. 09/675,796, filed on Sep. 29, 2000, by Stuart P. Kaler and entitled "System and Method for Managing Terminal Units in a Wireless System," now U.S. Statutory Invention Registration No. H2059.

TECHNICAL FIELD OF THE INVENTION

This invention relates generally to the field of communications, and more specifically to a system and method for managing base stations in a wireless system.

BACKGROUND OF THE INVENTION

Wireless networks typically allow terminal units to transmit and receive information over a wireless interface. Conventional terminal units include wireless telephones and computing devices connected to wireless modems. Base stations communicate with the terminal units over the wireless interface. The base stations establish, maintain, and release communications channels over the wireless interface, and the terminal units communicate with the base stations through the communications channels.

Typical wireless networks include an operations and maintenance center that manages the operations of the base stations. The operations and maintenance center usually manages the base stations by issuing management messages to one or more of the base stations. The base stations may also send responses and messages to the operations and maintenance center. In typical wireless networks, the management messages sent between the base stations and the operations and maintenance center travel through several intermediate network nodes, such as a base station controller.

Conventional wireless networks use a cascaded management scheme to manage the base stations. One or more intermediate nodes between the operations and maintenance center and the base stations perform mediation functions, translating the management messages from one format to another format that is understood by the intermediate node. For example, in conventional wireless networks, the base station controller receives management messages from the operations and maintenance center, translates the messages, and forwards the translated messages to the base stations.

A problem with this approach is that it increases the complexity of the wireless network. Components in the network typically need to include mediation functionality in order to communicate with other elements in the wireless network. The mediation functionality allows the network components to receive a management message, convert the message into a different protocol, and route the translated message to another element in the network. The mediation functionality makes the network elements more complex, which increases the development time and the expense of each element. This also increases the complexity and expense of the network.

Another problem with this approach is that it increases the load on the network components. The network components typically must receive and process the management messages, converting the messages from one format to another. The network components are unable to process other messages at this time. When a large number of management messages are being sent in the wireless network, elements in the network may spend an excessive amount of time translating the management messages, rather than performing other tasks in the network.

In addition, modularity typically cannot be maintained in the wireless network. The network components usually include proprietary management interfaces, which may prevent some of those components from properly communicating with one another. To properly transport management messages in the network, the components installed in the network need to understand the proprietary interfaces used by other components in the network. If a component cannot understand a proprietary interface in another component, the components may be unable to communicate effectively, and the network may be unable to transport management messages between the components. Because of the proprietary interfaces, a network operator is typically limited in the types of equipment that can be purchased and installed in the network.

SUMMARY OF THE INVENTION

In accordance with the present invention, a system and method for managing base stations in a wireless system are provided that substantially reduce or eliminate disadvantages and problems associated with previously developed systems and methods.

In one embodiment of the present invention, a communications system includes a base station operable to communicate with a terminal unit over a wireless interface, and a packet network coupled to the base station and operable to communicate with the base station. The communications system also includes a network management system coupled to the packet network. The network management system is operable to generate a management message to manage the base station. The network management system is also operable to transparently communicate the management message to the base station and to transparently receive a response to the management message from the base station.

In another embodiment of the present invention, a method for managing base stations in a wireless system includes generating a management message for the base station. The method also includes transparently communicating the management message from a network management system to the base station. The method further includes transparently receiving a response to the management message at the network management system from the base station.

Embodiments of the invention provide numerous technical advantages. For example, in one embodiment of the invention, a communications system is provided that uses less complex elements. In a particular embodiment, the system provides protocol layers for direct communications between a network management system and the base stations. The protocol layers allow management messages to be transported between the network management system and the base stations transparently. The network management system may manage the base stations in the system without other intermediate network components, such as base station controllers, performing mediation functions. The components in the system do not require mediation functionality, which reduces the complexity and expense of the components in the system. This also helps reduce the complexity and expense of the communications system.

Some embodiments of the invention also decrease the load on the components in the system. The network management system and the base stations may communicate transparently across the intermediate system components. These system components are not required to perform any mediation functions, so the components are able to perform other tasks. When a large number of management messages are being sent in the wireless network, the system components are not spending excessive amounts of time translating the management messages.

In addition, some embodiments of the invention help maintain modularity in the network. The components in the system may not need to understand proprietary management interfaces to function properly. By providing protocol layers for communications between the network management system and the base stations, the management messages may be communicated transparently between those elements, even if proprietary interfaces are used in the network components. Other equipment in the network, like base station controllers, may be installed without determining whether they can perform mediation functions for the management messages. The base stations controllers may properly transport the management messages in the network without understanding the proprietary management interfaces used in other elements in the network.

Other technical advantages are readily apparent to one of skill in the art from the attached Figures, description, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and for further features and advantages, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a block diagram illustrating an exemplary communications system;

FIG. **2** is a block diagram illustrating an exemplary network management architecture for the communications system of FIG. **1**;

FIG. **3** is a block diagram illustrating an exemplary management protocol architecture for managing base stations in the communications system of FIG. **1**;

FIG. **4** is a block diagram illustrating an exemplary management protocol architecture for managing terminal units in the communications system of FIG. **1**;

FIG. **5** is a flow diagram illustrating an exemplary method for managing base stations at a network management system;

FIG. **6** is a flow diagram illustrating an exemplary method for responding to a management message at a base station;

FIG. **7** is a flow diagram illustrating an exemplary method for managing terminal units at a network management system; and

FIG. **8** is a flow diagram illustrating an exemplary method for responding to a management message at a terminal unit.

DETAILED DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention and its advantages are best understood by referring to FIGS. **1** through **8** of the drawings, like numerals being used for like and corresponding parts of the various drawings.

FIG. **1** is a block diagram illustrating an exemplary communications system **10**. In the illustrated embodiment, system **10** comprises a plurality of terminal units **12**, a base station (BTS) **14**, an access router **16**, a private packet network **18**, a network management system **20**, a circuit-switched gateway **22**, a gatekeeper **24**, and a packet-switched gateway **26**. Other embodiments of system **10** may be used without departing from the scope of the present invention.

Each terminal unit **12** communicates with base station **14** over a wireless interface **28**. Terminal unit **12** provides packet voice, fax, and/or data services to a subscriber of system **10** by exchanging packets of data with base station **14**. Each terminal unit **12** may be uniquely identified in system **10** by a network address, such as an Internet Protocol (IP) address. The network address may be statically or dynamically assigned. Terminal unit **12** may comprise any device capable of communicating with base station **14** over wireless interface **28**. Terminal unit **12** could, for example, comprise a computer **30** coupled to a wireless modem **32**. Computer **30** may support packet data, fax, and/or voice applications executed by the subscriber. A telephone **34** or a fax machine could also be coupled to computer **30**. Other embodiments of terminal unit **12** may be used without departing from the scope of the present invention. For example, terminal unit **12** could also comprise a mobile telephone, such as a Global System for Mobile communication (GSM) mobile station.

Wireless interface **28** communicatively couples terminal unit **12** and base station **14**. In this document, the term "wireless" designates the use of a radio or over-the-air interface to communicate with terminal unit **12**. Wireless interface **28** may comprise any suitable circuit-switched or packet-switched wireless interface. Wireless interface **28** may, for example, comprise a GSM Enhanced Data rates for GSM Evolution (GSM/EDGE) interface.

Base station **14** is coupled to access router **16**. In this document, the term "couple" refers to any direct or indirect connection between two or more elements in system **10**, whether or not those elements physically contact one another. Base station **14** provides bi-directional communication with one or more terminal units **12** in a specified geographic area. For example, base station **14** transmits and receives packet messages to and from terminal units **12** over wireless interface **28**. Base station **14** also transmits and receives packet messages to and from private network **18** through access router **16**. Each base station **14** may be uniquely identified in system **10** by a network address, such as an IP address. The network address may be statically or dynamically assigned. Base station **14** may comprise any suitable device operable to facilitate communication with terminal units **12**. Base station **14** may, for example, comprise one or more radio transceivers capable of transmitting packet-switched messages to and receiving messages from terminal unit **12** over wireless interface **28**.

Access router **16** is coupled to base station **14** and private network **18**. Access router **16** routes packets containing voice, fax, and/or data traffic in system **10**. Access router **16** receives packets from base station **14** and routes the packets over private network **18**. Access router **16** also receives packets from private network **18** for a terminal unit **12** served by base station **14**, and access router **16** routes the packets to base station **14**. Access router **16** may comprise any suitable device operable to route messages over private network **18**. Access router **16** could, for example, comprise a wireless router and concentrator.

Private network **18** is coupled to access router **16**, network management system **20**, circuit-switched gateway **22**, gatekeeper 24, and packet-switched gateway 26. Private network 18 facilitates communication between components in system 10 by transferring messages between the components. Private network 18 may comprise any suitable packet network, such as a local area network (LAN), a metropolitan area network (MAN), a wide area network (WAN), or any other communications system or systems at one or multiple locations.

Network management system 20 provides management functionality in system 10. Network management system 20 may communicate with other components in system 10 over a management plane. The management plane carries management messages between network management system 20 and the components in system 10. In the illustrated embodiment, network management system 20 comprises a subscriber management platform (SMP) 36 and an operations support system (OSS) 38.

SMP 36 is coupled to private network 18. SMP 36 provides subscriber management and billing functionality in system 10. This may include, for example, authentication functionality to protect against fraud and customer registration functionality to collect customer data used in provisioning services and billing customers. This may also include rating functionality to create flexible pricing plans for subscribers, billing functionality to generate real-time or invoice customer bills, and customer management functionality to provide access to customer profiles, activities, and account balances. SMP 36 may comprise any suitable device operable to provide subscriber management functionality.

OSS 38 is coupled to private network 18. OSS 38 provides network management functionality to manage the components in system 10. This may include, for example, provisioning, administration, status, and performance monitoring functionality for the networks components in system 10. This may also include configuration, fault, and security management. OSS 38 may comprise any suitable device operable to provide network management functionality. In one embodiment, OSS 38 may be identified by a network address, such as a statically or dynamically assigned IP address.

Circuit-switched gateway 22 is coupled to private network 18, gatekeeper 24, and a public switched circuit network (SCN) 40. SCN 40 may comprise any suitable circuit-switched network, such as a public switched telephone network (PSTN) or an integrated services digital network (ISDN). Gateway 22 facilitates communication between system 10 and SCN 40 by transferring messages between private network 18 and SCN 40. Gateway 22 also performs an interworking function to translate between the packet-switched transmission and signaling protocols used by private network 18 and the circuit-switched protocols used by SCN 40. In one embodiment, system 10 uses the protocols defined by the International Telecommunications Union—Telecommunications (ITU-T) H.323 standard, and gateway 22 interworks the H.323 signaling protocols with the circuit switched protocols of SCN 40. Gateway 22 may comprise any suitable device operable to facilitate communication between system 10 and SCN 40. Gateway 22 may, for example, comprise an H.323 gateway.

Gatekeeper 24 is coupled to private network 18, circuit-switched gateway 22, and packet-switched gateway 26. Gatekeeper 24 provides call control services in system 10. This may include, for example, tracking the location of each terminal unit 12 and routing messages to and from the base station 14 currently serving a particular terminal unit 12. This may also include address translation to map between

the telephone number and current EP address of a terminal unit 12. Gatekeeper 24 may comprise any suitable device operable to provide call control services in system 10. In one embodiment, gatekeeper 24 comprises an H.323 gatekeeper.

Packet-switched gateway 26 is coupled to private network 18, gatekeeper 24, and a public packet-switched network 42. Public packet-switched network 42 may comprise any suitable packet-switched network, such as the Internet, a LAN, a MAN, a WAN, or any other communications system or systems in one or multiple locations. Packet-switched gateway 26 facilitates communication between system 10 and public network 42 by transferring messages between private network 18 and public network 42. Gateway 26 may comprise any suitable device operable to facilitate communication between system 10 and public network 42. Gateway 26 may, for example, comprise an access router that supports routing and firewalling functionality.

In operation, network management system 20 manages base stations 14 by transmitting management messages to base stations 14 over private network 18. Network management system 20 also manages terminal units 12 by transmitting management messages to terminal units 12 over private network 18 and wireless interface 28. In one embodiment, network management system 20 communicates the management messages to terminal units 12 and/or base stations 14 transparently in system 10. In this document, the term "transparently" refers to a communication between two elements in system 10, where components in system 10 that link the two elements do not perform a mediation function to translate the management messages. Network management system 20 and base station 14 may communicate transparently across private network 18. Network management system 20 and terminal unit 12 may also communicate transparently over private network 18 and wireless interface 28. The components in system 10 that link network management system 20, terminal units 12, and base stations 14 do not perform a mediation function to translate the management messages.

FIG. 2 is a block diagram illustrating an exemplary network management architecture 50 for communications system 10 of FIG. 1. In the illustrated embodiment, network management architecture 50 comprises SMP 36, a network node management (NNM) platform 60, a gateway management platform 62, a router management platform 64, a wireless access network management platform 66, a local area network (LAN) 68, and a router 70. Other embodiments of network management architecture 50 may be used without departing from the scope of the present invention.

NNM platform 60 is coupled to LAN 68. NNM platform 60 provides an integrated management platform for the various components in system 10, such as terminal units 12, base stations 14, routers 16, and gateways 22 and 26. NNM platform 60 provides network management functionality such as configuration, fault, performance monitoring, event management, database control, general security, trouble management, and asset management functionality. In addition, NNM platform 60 may provide application programming interfaces (APIs) that allow additional applications to be executed on NNM platform 60. These additional applications could include, for example, analysis tools used in system 10. NNM platform 60 may comprise any suitable device operable to provide integrated network management in system 10.

Gateway management platform 62 is coupled to LAN 68. Gateway management platform 62 provides management functionality to control circuit-switched gateway 22. Gateway management platform **62** may provide provisioning, administration, status, and performance monitoring functionality for gateway **22**. Gateway management platform **62** may comprise any suitable device operable to provide management functionality for gateway **22**. Gateway management platform **62** could, for example, comprise an H.323 gateway management platform.

Router management platform **64** is coupled to LAN **68**. Router management platform **64** provides management functionality to control access routers **16**, packet-switched gateway **26**, and router **70** in system **10**. Router management platform **64** may provide provisioning, administration, status, and performance monitoring functionality for routers **16** and **70** and gateway **26**. Router management platform **64** may comprise any suitable device operable to provide management functionality for routers **16** and **70** and gateway **26**.

Wireless access network management platform **66**, also called a wireless management platform, is coupled to LAN **68**. Wireless management platform **66** provides management functionality to control terminal units **12** and base stations **14** in system **10**. Wireless management platform **66** may comprise any suitable device operable to provide management functionality for terminal units **12** and base stations **14** in system **10**.

LAN **68** couples NNM platform **60**, gateway management platform **62**, router management platform **64**, and wireless management platform **66** to router **70**. LAN **68** facilitates communication between components in network management architecture **50** and system **10**. LAN **68** may, for example, transfer management messages between components in network management architecture **50** and router **70**. LAN **68** may comprise any suitable packet network.

Router **70** is coupled to LAN **68** and private packet network **18**. Router **70** facilitates communication between network management architecture **50** and system **10**. Router **70** may, for example, transfer management messages between LAN **68** and components of system **10** coupled to private network **18**. Router **70** may comprise any suitable device operable to route management messages over private network **18**. Router **70** may, for example, comprise a unicast router or a multicast router.

In operation, router **70** receives management messages for terminal units **12** and/or base stations **14** from wireless management platform **66**, and router **70** routes the messages over private network **18**. Router **70** also receives responses and messages from terminal units **12** and/or base stations **14**, and router **70** routes the messages to wireless management platform **66** over LAN **68**.

Router **70** routes management messages to base stations **14** using the network address of base stations **14**. In one embodiment, router **70** comprises a unicast router, and router **70** routes management messages to a base station **14** using the network address of that base station **14**. In another embodiment, router **70** comprises a multicast router, and router **70** may route a management message to one base station **14** or groups of base stations **14**. Multicast router **70** may also broadcast the message to all base stations **14**. In a particular embodiment, each base station **14** supports the Internet Group Membership Protocol, which allows base stations **14** to inform multicast router **70** of the group membership of each base station **14**.

Similarly, router **70** routes management messages to terminal units **12** using the network address of terminal units **12**. In one embodiment, router **70** comprises a unicast router, and router **70** routes management messages to a terminal unit **12** using the network address of that terminal unit **12**. In another embodiment, router **70** comprises a multicast router, and router **70** may route a management message to one terminal unit **12**, groups of terminal units **12**, or all terminal units **12**. In a particular embodiment, each terminal unit **12** supports the Internet Group Membership Protocol, which allows terminal units **12** to inform multicast router **70** of the group membership of each terminal unit **12**.

FIG. **3** is a block diagram illustrating an exemplary management protocol architecture **100** for managing base stations **14** in communications system **10** of FIG. **1**. In the illustrated embodiment, management protocol architecture **100** comprises a wireless access management protocol stack **120**, a router protocol stack **140**, an access router protocol stack **150**, and a base station protocol stack **160**. Other embodiments of management protocol architecture **100** may be used without departing from the scope of the present invention.

Wireless access management protocol stack **120** comprises an application layer **121**, a User Datagram Protocol (UDP) layer **128**, a Transmission Control Protocol (TCP) layer **130**, an Internet Protocol (IP) layer **132**, and an Ethernet layer **134**. Application layer **121** comprises a manager application **122**, a Simple Network Management Protocol (SNMP) entity **124**, and a File Transfer Protocol/Multicast File Transfer Protocol (FTP/MFTP) entity **126**.

Router protocol stack **140** comprises an Ethernet layer **142**, an IP layer **144**, and a frame relay layer **146**. Access router protocol stack **150** comprises a frame relay layer **152**, an IP layer **154**, and a frame relay layer **156**. Base station protocol stack **160** comprises an application layer **161**, a UDP layer **168**, a TCP layer **170**, an IP layer **172**, and a frame relay layer **174**. Application layer **161** comprises an agent application **162**, a SNMP entity **164**, and a FTP/MFTP entity **166**.

Application layers **121** and **161** support the execution of management applications **122** and **162** to manage base stations **14** in system **10**. In one embodiment, system **10** uses a Telecommunications Management Network (TMN) architecture. In this embodiment, communications between application layers **121** and **161** occur across TMN interfaces that use a manager-agent relationship. In a particular embodiment, system **10** adheres to the TMN principles in the International Telegraph and Telephone Consultative Committee (CCITT) Recommendation M.3010, entitled "Principles of a Telecommunications Management Network."

Applications **122** and **162** use SNMP entities **124** and **164** and FTP/MFTP entities **126** and **166** to manage base stations **14**. SNMP entities **124** and **164** support network management operations, and FTP/MFTP entities **126** and **166** support file transfer operations in system **10**. Applications **122** and **162** may use SNMP entities **124** and **164** and FTP/MFTP entities **126** and **166** to construct complex management operations.

UDP layers **128** and **168**, along with IP layers **132**, **144**, **154**, and **172**, support the use of UDP/IP connections between wireless management platform **66** and base stations **14**. TCP layers **130** and **170**, along with IP layers **132**, **144**, **154**, and **172**, support the use of TCP/IP connections between wireless management platform **66** and base stations **14**. SNMP entities **124** and **164** use the UDP/IP connections to transport SNMP messages in system **10**. FTP/MFTP entities **126** and **166** also use the UDP/IP connections to perform multicasting operations, while FTP/MFTP entities **126** and **166** use the TCP/IP connections to transport negative acknowledgement signals from base stations **14**.

Ethernet layers **134** and **142** support the physical communications link between wireless management platform **66** and router **70**. Frame relay layers **146** and **152** support the physical communications link between router **70** and access router **16**. Frame relay layers **156** and **174** support the physical communications link between access router **16** and base station **14**. In one embodiment, frame relay layers **146**, **152**, **156**, and **174** may not support multicast operations, and point-to-multipoint routing is performed in IP layers **144**, **154**, and **172** using a separate virtual circuit for each base station **14**.

As illustrated in FIG. **3**, router **70** and access router **16** transport management messages between wireless management platform **66** and base station **14** without performing any mediation functions. The management messages pass transparently between wireless management platform **66** and base station **14**. This allows system **10** to use less complex components since the components do not require mediation functionality. It also decreases the load on router **70** and access router **16** because they are not required to perform mediation functions, so router **70** and access router **16** are able to perform other tasks. Further, router **70** and access router **16** may not need to understand proprietary management interfaces used by other components to properly transport the management messages in system **10**.

FIG. **4** is a block diagram illustrating an exemplary management protocol architecture **200** for managing terminal units **12** in communications system **10** of FIG. **1**. In the illustrated embodiment, management protocol architecture **200** comprises wireless access management protocol stack **120**, router protocol stack **140**, access router protocol stack **150**, base station protocol stack **160**, and a terminal unit protocol stack **220**. Other embodiments of management protocol architecture **200** may be used without departing from the scope of the present invention.

Management protocol architecture **200** uses several protocol layers in wireless access management protocol stack **120**, router protocol stack **140**, access router protocol stack **150**, and base station protocol stack **160** from management protocol architecture **100**. In addition, wireless access management protocol stack **120** comprises another application manager application **136**. Base station protocol stack **160** further comprises a radio interface layer **176**, a Radio Link Control / Medium Access Control (RLC/MAC) layer **178**, a Logical Link Control (LLC) layer **180**, and a Subnetwork Dependent Convergence Protocol (SNDCP) layer **182**. Terminal unit protocol stack **220** comprises an application layer **221**, a UDP layer **228**, a TCP layer **230**, an IP layer **232**, a SNDCP layer **234**, a LLC layer **236**, a RLC/MAC layer **238**, and a radio interface layer **240**. Application layer **221** comprises an agent application **222**, a SNMP entity **224**, and a FTP/MFTP entity **226**.

Application layers **121** and **221** support the execution of management applications **136** and **222** to manage terminal units **12**. SNMP entities **124** and **224** support network management operations, and FTP/MFTP entities **126** and **226** support file transfers in system **10**. Applications **136** and **222** may use SNMP entities **124** and **224** and FTP/MFTP entities **126** and **226** to construct complex management operations to provide broad management capabilities over terminal units **12**.

UDP layers **128** and **228**, along with IP layers **132**, **144**, **154**, and **232**, support the use of UDPIIP connections between wireless management platform **66** and terminal units **12**. TCP layers **130** and **230**, along with IP layers **132**, **144**, **154**, and **232**, support the use of TCP/IP connections between wireless management platform **66** and terminal units **12**. SNMP entities **124** and **224** use the UDP/IP connections to transport SNMP messages in system **10**. FTP/MFTP entities **126** and **226** also use the UDP/IP connections to perform multicasting operations, while FTP/MFTP entities **126** and **226** use the TCP/IP connections to transport negative acknowledgement signals from terminal units **12**. Frame relay layers **146**, **152**, **156**, and **162** may not support multicast operations, so point-to-multipoint routing may be performed in IP layers **144** and **154** using a separate virtual circuit for each base station **14**. Base station **14** then forwards the messages to the appropriate terminal unit **12**.

Radio interface layers **176** and **240** manage wireless interface **28** between terminal unit **12** and base station **14**. RLC/MAC layers **178** and **238** support the transfer of information over radio interface layers **176** and **240**. RLC/MAC layers **178** and **238** may, for example, map LLC frames from LLC layers **180** and **236** onto RLC frames transmitted over wireless interface **28**. LLC layers **180** and **236** provide a reliable ciphered logical link between terminal unit **12** and base station **14**, and messages are transferred between LLC layers **180** and **236** in LLC frames. SNDCP layers **182** and **234** map messages having a network-level protocol, such as an IP protocol, onto LLC frames for transport between terminal unit **12** and base station **14**. SNDCP layers **182** and **234** also perform encryption, header compression, and data compression of network-layer messages.

As illustrated in FIG. **4**, base station **14**, access router **16**, and router **70** transport management messages between wireless management platform **66** and terminal units **12** without performing any mediation functions. The management messages pass transparently between wireless management platform **66** and terminal units **12**. This also allows system **10** to use less complex components and to decrease the load on base stations **14**, access router **16**, and router **70**. It also allows base stations **14**, access router **16**, and router **70** to transport management messages in system **10** without understanding proprietary interfaces used by the components in system **10**.

FIG. **5** is a flow diagram illustrating an exemplary method for managing base stations **14** at network management system **20**. Network management system **20** generates a management message for one or more base stations **14** at a step **400**. This may include, for example, wireless management platform **66** generating the message. Wireless management platform **66** communicates the management message to router **70** at a step **402**. Router **70** transparently routes the management message to one or more of the base stations **14** at a step **404**. This may include, for example, router **70** routing the message over packet network **18** to access routers **16** coupled to base stations **14**. Router **70** may use the network addresses of the base stations **14** to route the message to base stations **14**. Router **70** may also use Internet Group Messaging Protocol messages received from base stations **14** to multicast the management message to base stations **14**. Router **70** receives a response to the management message at a step **406**. The response may be communicated transparently from base station **14**. Router **70** communicates the response to wireless management platform **66** at a step **408**. This may include, for example, router **70** communicating the response over LAN **68** to wireless management platform **66**.

FIG. **6** is a flow diagram illustrating an exemplary method for responding to a management message at base station **14**. Base station **14** receives a management message from network management system **20** at a step **440**. This may include, for example, access router **16** receiving the management message over private network **18** and forwarding the message to base station **14**. Base station **14** performs a function requested by the management message at a step **442**. The function may comprise any suitable management function capable of execution by base station **14**. This may include, for example, base station **14** determining a current status of each transceiver in base station **14**.

Base station **14** generates a response to the management message at a step **444**. The response may indicate that base station **14** performed some action, or the response may include information requested by network management system **20**. Base station **14** transparently communicates the response to network management system **20**. Base station **14** communicates the response to access router **16** at a step **446**, and access router **16** routes the response to network management system **20** at a step **448**. This may include, for example, access router **16** routing the response to network management system **20** using the network address of OSS **38**.

FIG. **7** is a flow diagram illustrating an exemplary method for managing terminal units **12** at network management system **20**. Network management system **20** generates a management message for one or more terminal units **12** at a step **480**. This may include, for example, wireless management platform **66** generating the message. Wireless management platform **66** communicates the management message to router **70** at a step **482**. Router **70** routes the management message to one or more of the terminal units **12** at a step **484**. This may include, for example, router **70** routing the message to base stations **14** that are currently serving terminal units **12**. Router **70** may use the network addresses of the terminal units **12** to route the message to terminal units **12**. Router **70** may also use Internet Group Messaging Protocol messages received from terminal units **12** to multicast the management message to terminal units **12**. Router **70** receives a response to the management message at a step **486**. The response may be communicated transparently from base station **14**. Router **70** communicates the response to wireless management platform **66** at a step **488**. This may include, for example, router **70** communicating the response over LAN **68** to wireless management platform **66**.

FIG. **8** is a flow diagram illustrating an exemplary method for responding to a management message at terminal unit **12**. Terminal unit **12** receives a management message from network management system **20** at a step **520**. This may include, for example, access router **16** receiving the management message over private network **18** and communicating the message to base station **14** serving terminal unit **12**, and base station **14** communicating the message to terminal unit **12** over wireless interface **28**. Terminal unit **12** performs a function requested by the management message at a step **522**. The function may comprise any suitable management function capable of execution by terminal unit **12**. This may include, for example, determining a current status of terminal unit **12**.

Terminal unit **12** generates a response to the management message at a step **524**. The response may indicate that terminal unit **12** performed some action, or the response may include information requested by network management system **20**. Terminal unit **12** transparently communicates the response to network management system **20**. Terminal unit **12** communicates the response to access router **16** through base station **14** at a step **526**, and access router **16** routes the response to network management system **20** at a step **528**. This may include, for example, access router **16** routing the response to network management system **20** using the network address of OSS **38**.

Although the present invention has been described in several embodiments, a myriad of changes, variations, alterations, transformations, and modifications may be suggested to one skilled in the art, and it is intended that the present invention encompass such changes, variations, alterations, transformations, and modifications as fall within the spirit and scope of the appended claims.

What is claimed is:

1. A method for managing base stations in a wireless system, comprising:

generating a management message for the base station;

transparently communicating the management message from a network management system to the base station; and

transparently receiving a response to the management message at the network management system from the base station.

2. The method of claim **1**, wherein communicating the message to the base station comprises communicating the message to a router coupled to a packet network.

3. The method of claim **2**, wherein communicating the message to the base station further comprises communicating the message from the router to an access router coupled to the base station and the packet network.

4. The method of claim **1**, wherein communicating the message to the base station comprises communicating the message to the base station using an Internet Protocol address of the base station.

5. The method of claim **1**, wherein communicating the message to the base station comprises multicasting the message to a plurality of base stations.

6. The method of claim **5**, further comprising receiving an Internet Group Membership Protocol (IGMP) message from each base station, and wherein multicasting the message to the plurality of base stations comprises multicasting the messages to the plurality of base stations using the IGMP messages from the base stations.

7. The method of claim **5**, wherein receiving a response to the management message from the base station comprises receiving a response to the management message from each of the plurality of base stations.

8. A communications system, comprising:

a base station operable to communicate with a terminal unit over a wireless interface;

a packet network coupled to the base station and operable to communicate with the base station; and

a network management system coupled to the packet network, the network management system operable to generate a management message to manage the base station, the network management system also operable to transparently communicate the management message to the base station and to transparently receive a response to the management message from the base station.

9. The communications system of claim **8**, wherein the packet network comprises an Internet Protocol network.

10. The communications system of claim **8**, wherein the network management system comprises:

a gateway management platform operable to manage a circuit-switched gateway coupled to the packet network;

a router management platform operable to manage a router coupled to the packet network; and

a wireless management platform operable to manage the base station.

11. The communications system of claim **8**, further comprising a router coupled to the network management system and the packet network, the router operable to communicate the management message to the base station and to receive the response from the base station.

12. The communications system of claim **11**, wherein the base station comprises a first base station;

further comprising a second base station coupled to the packet network; and

wherein the router comprises a multicast router operable to communicate the management message to the first and second base stations.

13. The communications system of claim **12**, wherein the network management system is operable to transparently receive a response to the management message from the first and second base stations.

14. The communications system of claim **8**, further comprising:

a circuit-switched gateway coupled to the packet network and operable to communicate with a circuit-switched network; and

a packet-switched gateway coupled to the packet network and operable to communicate with another packet network.

15. A network management system for managing base stations in a wireless system, comprising:

a router operable to communicate with the base station through a packet network; and

a wireless management platform coupled to the router, the wireless management platform operable to generate a management message to manage the base station, the wireless management platform also operable to transparently communicate the management message to the base station and to transparently receive a response to the management message from the base station.

16. The network management system of claim **15**, further comprising a local area network coupled to the router and the wireless management platform, the local area network operable to transfer the management message and the response between the wireless management platform and the router.

17. The network management system of claim **15**, wherein the router communicates the message to the base station using an Internet Protocol address of the base station.

18. The network management system of claim **15**, wherein the router comprises a multicast router operable to multicast the management message to a plurality of base stations coupled to the packet network.

19. The network management system of claim **18**, wherein the wireless management platform is operable to transparently receive a response to the management message from each of the plurality of base stations.

20. The network management system of claim **15**, further comprising:

a router management platform coupled to the router and operable to manage the router; and

a gateway management platform coupled to the router and operable to manage a circuit-switched gateway coupled to the packet network.

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