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Mauer et al.

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(54) **WIRELESS GEOGRAPHIC ROUTING PROTOCOL**

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H04W 72/00 (2009.01)

(52) **U.S. Cl.**
CPC ***H04W 72/00*** (2013.01)

(58) **Field of Classification Search**
USPC 370/310
See application file for complete search history.

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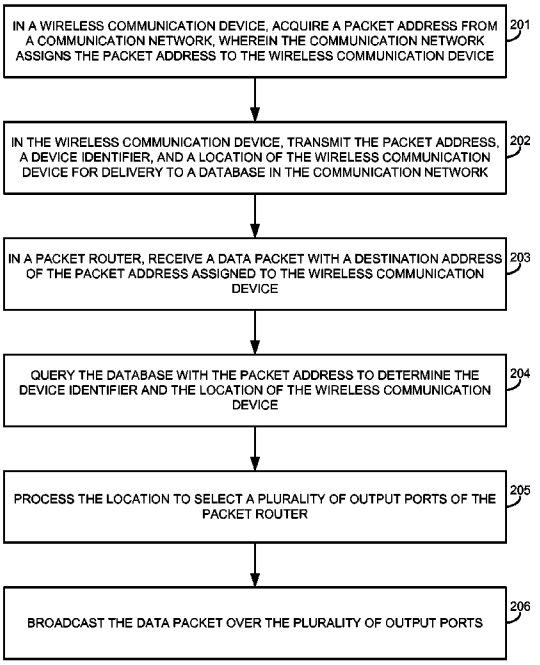
Primary Examiner — Sulaiman Nooristany

(57) **ABSTRACT**

A method of operating a communication system comprises, in a wireless communication device, acquiring a packet address from a communication network, wherein the communication network assigns the packet address to the wireless communication device, and transmitting the packet address, a device identifier, and a location of the wireless communication device for delivery to a database in the communication network. The method further comprises, in a packet router, receiving a data packet with a destination address of the packet address assigned to the wireless communication device, querying the database with the packet address to determine the device identifier and the location of the wireless communication device, processing the location to select a plurality of output ports of the packet router, and broadcasting the data packet over the plurality of output ports.

20 Claims, 6 Drawing Sheets



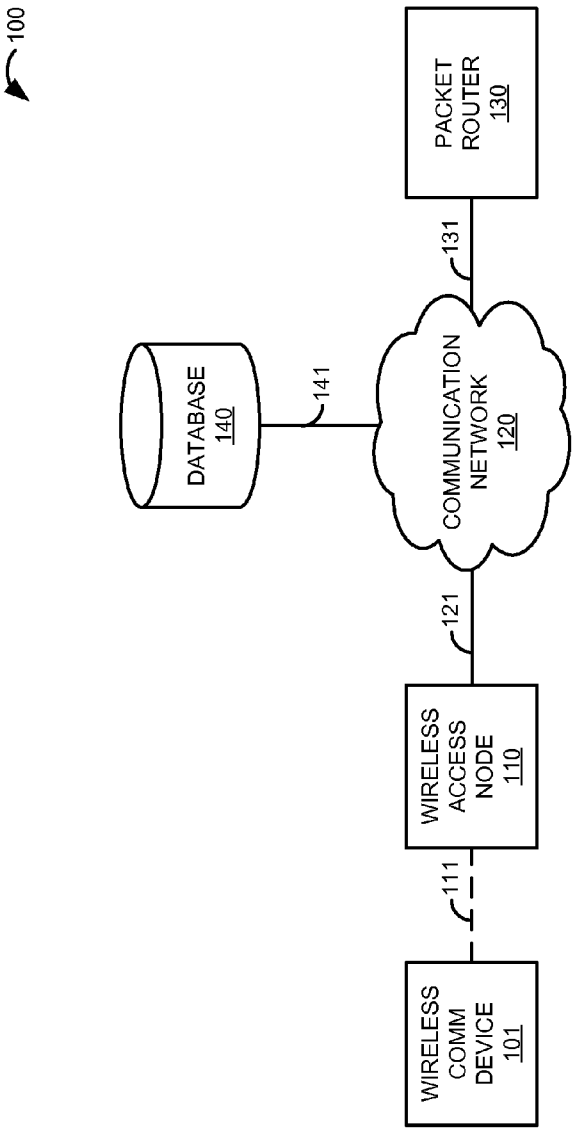

100
PACKET ROUTER 130
131
DATABASE 140
141
COMMUNICATION NETWORK 120
121
WIRELESS ACCESS NODE 110
111
WIRELESS COMM DEVICE 101

FIGURE 1

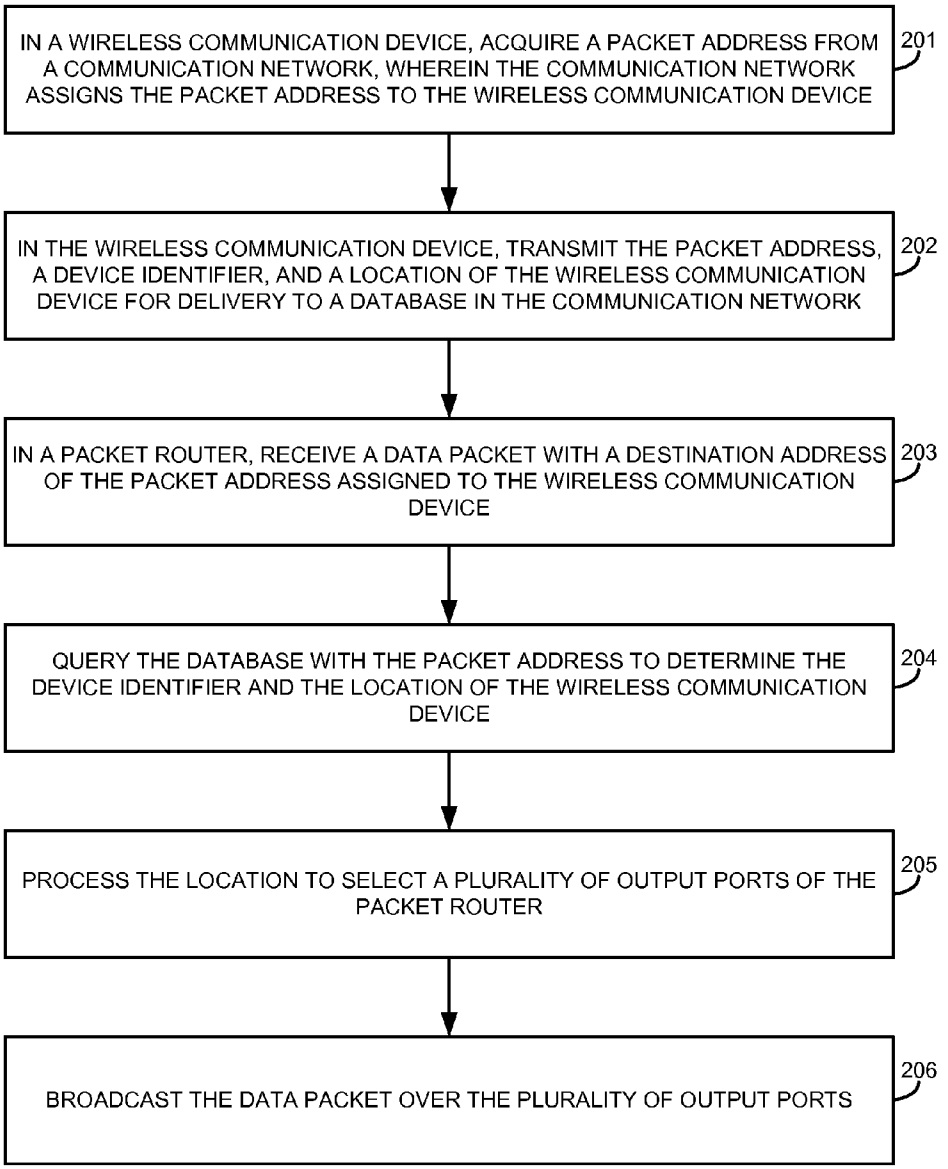

IN A WIRELESS COMMUNICATION DEVICE, ACQUIRE A PACKET ADDRESS FROM A COMMUNICATION NETWORK, WHEREIN THE COMMUNICATION NETWORK ASSIGNS THE PACKET ADDRESS TO THE WIRELESS COMMUNICATION DEVICE
201
IN THE WIRELESS COMMUNICATION DEVICE, TRANSMIT THE PACKET ADDRESS, A DEVICE IDENTIFIER, AND A LOCATION OF THE WIRELESS COMMUNICATION DEVICE FOR DELIVERY TO A DATABASE IN THE COMMUNICATION NETWORK
202
IN A PACKET ROUTER, RECEIVE A DATA PACKET WITH A DESTINATION ADDRESS OF THE PACKET ADDRESS ASSIGNED TO THE WIRELESS COMMUNICATION DEVICE
203
QUERY THE DATABASE WITH THE PACKET ADDRESS TO DETERMINE THE DEVICE IDENTIFIER AND THE LOCATION OF THE WIRELESS COMMUNICATION DEVICE
204
PROCESS THE LOCATION TO SELECT A PLURALITY OF OUTPUT PORTS OF THE PACKET ROUTER
205
BROADCAST THE DATA PACKET OVER THE PLURALITY OF OUTPUT PORTS
206

FIGURE 2

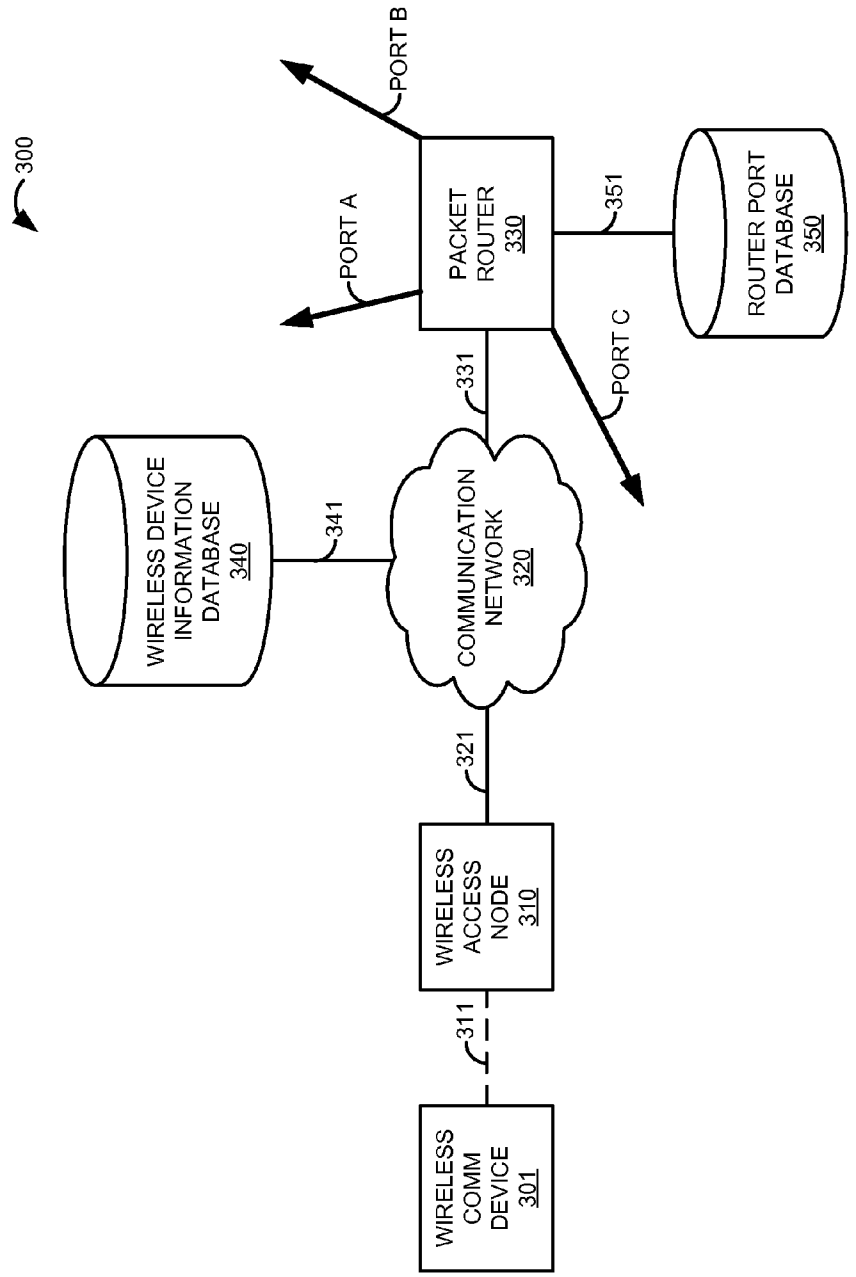

300
WIRELESS COMM DEVICE 301
311
WIRELESS ACCESS NODE 310
321
COMMUNICATION NETWORK 320
341
WIRELESS DEVICE INFORMATION DATABASE 340
331
PACKET ROUTER 330
PORT A
PORT B
PORT C
351
ROUTER PORT DATABASE 350

FIGURE 3

IP ADDRESS	MAC ADDRESS	GPS
24.17.95.181	00:1F:E2:53:57:32	RANGE 1
64.132.89.221	00:1D:FE:4A:81:01	RANGE 2
64.173.211.241	00:1D:FE:22:B2:DF	RANGE 3
144.232.79.121	00:1D:FE:A3:DD:40	RANGE 4
WIRELESS DEVICE INFORMATION DATABASE 340		

GPS	ROUTER PORTS
RANGE 1	A
RANGE 2	B + C
RANGE 3	A + C
RANGE 4	A + B + C
ROUTER PORT DATABASE 350	

FIGURE 4

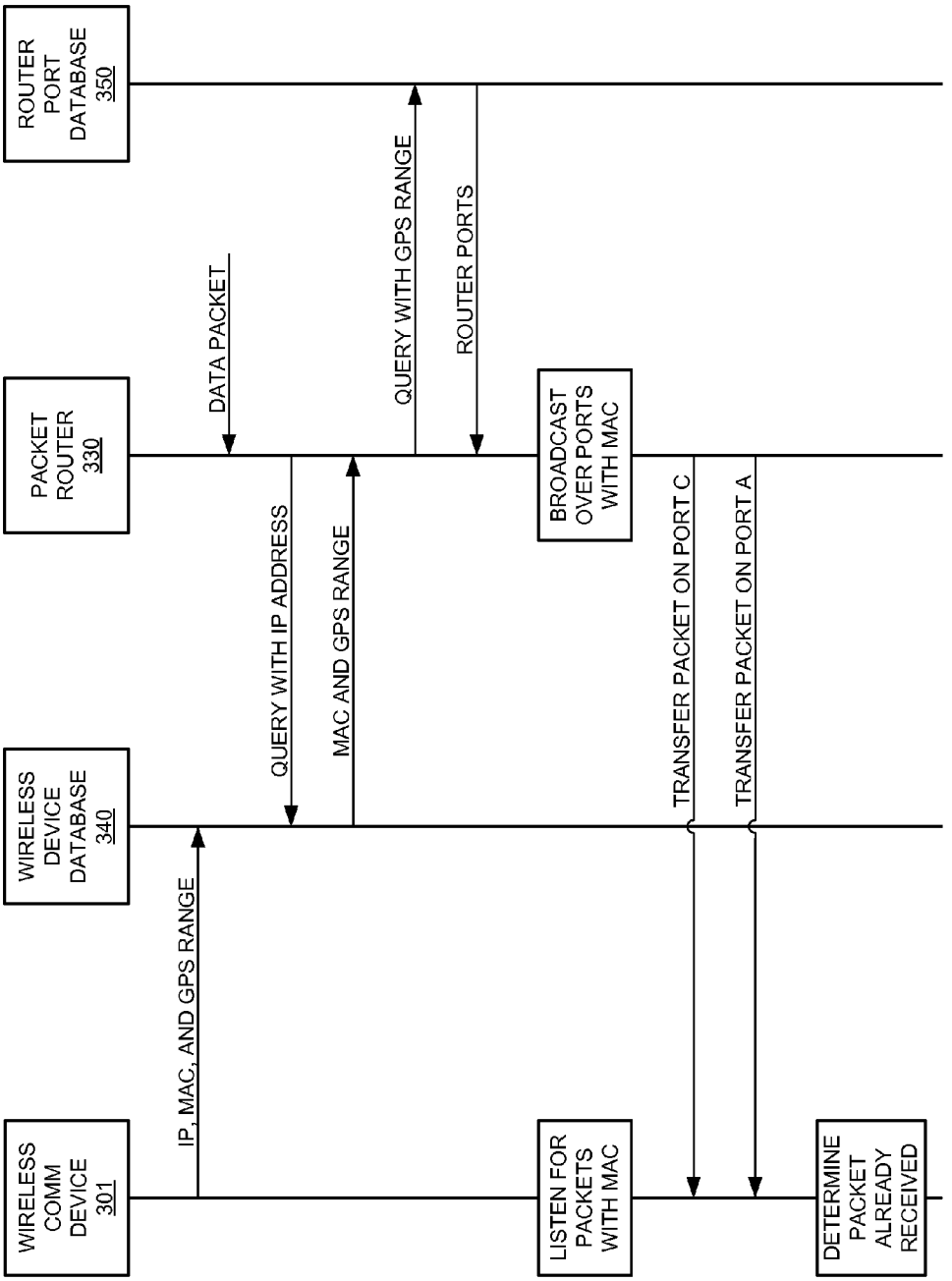

ROUTER PORT DATABASE 350
PACKET ROUTER 330
WIRELESS DEVICE DATABASE 340
WIRELESS COMM DEVICE 301
DATA PACKET
QUERY WITH GPS RANGE
ROUTER PORTS
QUERY WITH IP ADDRESS
MAC AND GPS RANGE
BROADCAST OVER PORTS WITH MAC
TRANSFER PACKET ON PORT C
TRANSFER PACKET ON PORT A
IP, MAC, AND GPS RANGE
LISTEN FOR PACKETS WITH MAC
DETERMINE PACKET ALREADY RECEIVED

FIGURE 5

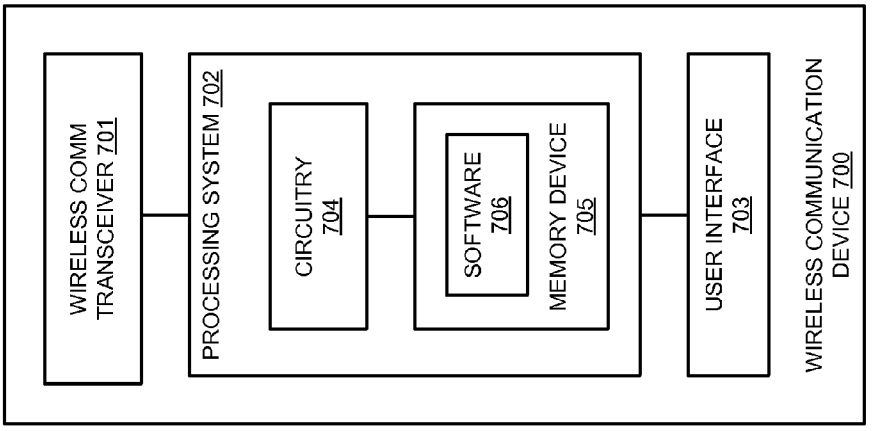


FIGURE 7

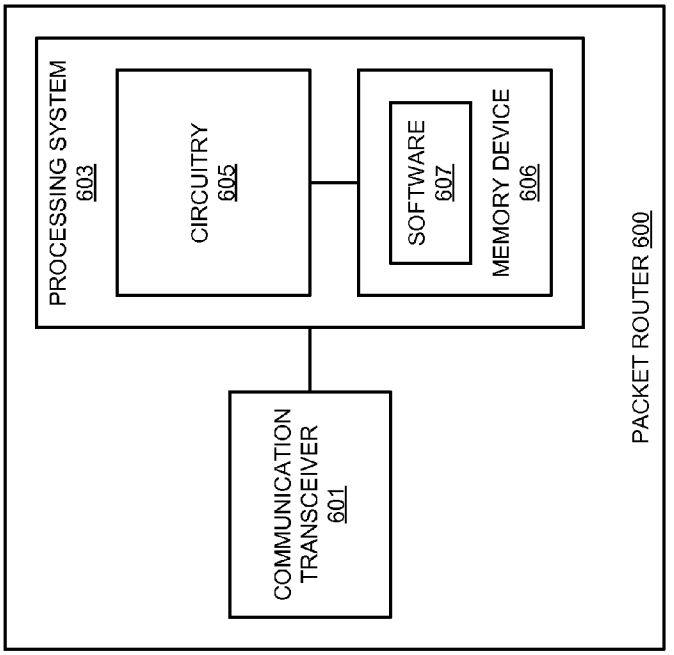


FIGURE 6

WIRELESS GEOGRAPHIC ROUTING PROTOCOL

TECHNICAL BACKGROUND

Wireless communications have become increasingly prominent for sending and receiving information. For example, individuals may utilize a wireless communication device for voice communications, research, entertainment, or for conducting critical business transactions. As wireless communications have increased, so have the number of wireless access modes used to support these communications. For example, many modern wireless communication devices are capable of communicating over both third generation (3G) and fourth generation (4G) wireless networks, often referred to as "dual-mode" devices. In addition, a wireless communication device may also communicate using other wireless protocols, such as Wi-Fi or Bluetooth.

In order to utilize a wireless communication device, a user typically operates the device to register with a communication network operated by a wireless communication service provider. Upon successful registration, a communication session is established in a particular wireless protocol. During the communication session, the user may send and receive data via the access network of the communication service provider. However, if a dual-mode wireless communication device transitions between access media, a new communication session is typically established. For example, when a wireless communication device transitions to a different access mode by switching from a 3G network to a 4G network, the 3G communication session would typically be torn down and a new communication session for the 4G network would be established.

Overview

A method of operating a communication system comprises, in a wireless communication device, acquiring a packet address from a communication network, wherein the communication network assigns the packet address to the wireless communication device, and transmitting the packet address, a device identifier, and a location of the wireless communication device for delivery to a database in the communication network. The method further comprises, in a packet router, receiving a data packet with a destination address of the packet address assigned to the wireless communication device, querying the database with the packet address to determine the device identifier and the location of the wireless communication device, processing the location to select a plurality of output ports of the packet router, and broadcasting the data packet over the plurality of output ports.

A communication system comprises a wireless communication device and packet router. The wireless communication device is configured to acquire a packet address from a communication network, wherein the communication network assigns the packet address to the wireless communication device, and transmit the packet address, a device identifier, and a location of the wireless communication device for delivery to a database in the communication network. The packet router is configured to receive a data packet with a destination address of the packet address assigned to the wireless communication device, query the database with the packet address to determine the device identifier and the location of the wireless communication device, process the location to select a plurality of output ports of the packet router, and broadcast the data packet over the plurality of output ports.

A method of operating a communication system comprises, in a wireless communication device, transmitting a packet address, a media access control address, and a location of the wireless communication device for delivery to a database in a communication network. The method further comprises, in a packet router, receiving a data packet with a destination address of the packet address assigned to the wireless communication device, querying the database with the packet address to determine the media access control address and the location of the wireless communication device, processing the location to select a plurality of output ports of the packet router, wherein each output port of the plurality of output ports communicates using a different wireless protocol of a plurality of wireless protocols, and broadcasting the data packet over the plurality of output ports. The method further comprises, in the wireless communication device, identifying the media access control address in the data packet, and receiving the data packet based on the media access control address.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram that illustrates a communication system.

FIG. **2** is a flow diagram that illustrates an operation of the communication system.

FIG. **3** is a block diagram that illustrates a communication system in an exemplary embodiment.

FIG. **4** illustrates tables in a wireless device information database and a router port database in an exemplary embodiment.

FIG. **5** is a sequence diagram that illustrates an operation of the communication system in an exemplary embodiment.

FIG. **6** is a block diagram that illustrates a packet router.

FIG. **7** is a block diagram that illustrates a wireless communication device.

DETAILED DESCRIPTION

The following description and associated drawings teach the best mode of the invention. For the purpose of teaching inventive principles, some conventional aspects of the best mode may be simplified or omitted. The following claims specify the scope of the invention. Some aspects of the best mode may not fall within the scope of the invention as specified by the claims. Thus, those skilled in the art will appreciate variations from the best mode that fall within the scope of the invention. Those skilled in the art will appreciate that the features described below can be combined in various ways to form multiple variations of the invention. As a result, the invention is not limited to the specific examples described below, but only by the claims and their equivalents.

FIG. **1** is a block diagram that illustrates communication system **100**. Communication system **100** includes wireless communication device **101**, wireless access node **110**, communication network **120**, packet router **130**, and database **140**. Wireless communication device **101** and wireless access node **110** are in communication over wireless communication link **111**. Wireless access node **110** and communication network **120** communicate over communication link **121**. Communication network **120** and packet router **130** are in communication over communication link **131**, while database **140** and communication network **130** communicate over communication link **141**.

FIG. **2** is a flow diagram that illustrates an operation of communication system **100**. The steps of the operation are indicated below parenthetically.

In FIG. **2**, wireless communication device **101** acquires a packet address from communication network **120** (**201**).

Communication network **120** assigns the packet address to wireless communication device **101** (**201**). In some examples, the packet address assignment to wireless communication device **101** could be static or dynamic, and wireless communication device **101** may acquire the packet address only once, such as during initial provisioning.

Wireless communication device **101** transmits the packet address, a device identifier, and a location of wireless communication device **101** for delivery to database **140** in communication network **120** (**202**). The device identifier could comprise any identifier associated with wireless communication device **101** and/or its user. For example, the device identifier could comprise a Media Access Control (MAC) address, Mobile Station International Subscriber Directory Number (MSISDN) or some other telephone number, Electronic Serial Number (ESN), Mobile Station Identifier (MSID), Mobile Equipment Identifier (MEID), International Mobile Equipment Identity (IMEI), International Mobile Subscriber Identity (IMSI), Media Access Control Identifier (MACID), User Identifier (UID), or some other identifier that uniquely identifies wireless communication device **101** and/or a user of device **101**—including combinations thereof. The location of wireless communication device **101** could comprise any level of specificity, from precise coordinates to a larger geographic area. For example, the location of wireless communication device **101** could be identified by global positioning system (GPS) coordinates or other GPS data, latitude/longitude, a sector of wireless access node **110** serving device **101**, or any other technique that determines a location of wireless communication device **101**. In some examples, the location is identified by a GPS range.

Once database **140** has been populated with the packet address, device identifier, and location of wireless communication device **101**, packet router **130** receives a data packet with a destination address of the packet address assigned to wireless communication device **101** (**203**). The data packet received by packet router **130** could comprise any datagram or other message intended for delivery to wireless communication device **101**. Responsive to receiving the data packet, packet router **130** queries database **140** with the packet address to determine the device identifier and the location of wireless communication device **101** (**204**). Since database **140** relates the packet address to the device identifier and the location of wireless communication device **101** as provided by device **101** in operation **202**, packet router **130** receives the device identifier and the location of wireless communication device **101** in response to the query.

Packet router **130** processes the location of wireless communication device **101** to select a plurality of output ports of the packet router **130** (**205**). Thus, packet router **130** typically selects the output ports based on the location of wireless communication device **101**. In some examples, each output port of the plurality of output ports on packet router **130** communicates using a different wireless protocol of a plurality of wireless protocols. In this case, packet router **130** could select output ports associated with the wireless protocols that have coverage in the location of wireless communication device **101**. In other examples, packet router **130** may select the output ports based on wireless protocols of which wireless communication device **101** is capable of communicating. For example, packet router **130** could process the device identifier of wireless communication device **101** to determine the wireless capabilities of device **101**, and select output ports that are associated with the wireless capabilities of wireless communication device **101**.

Packet router **130** typically serves an area including the location of wireless communication device **101**, so that the output ports selected by packet router **130** are within range of device **101**. However, in some examples, wireless communication device **101** may be traveling away from the location at some velocity. In this case, packet router **130** could determine the velocity of wireless communication device **101** based on a series of location updates associated with device **101** and timestamps corresponding to the location updates. Packet router **130** could then process the location to select the output ports of packet router **130** by determining if the velocity of wireless communication device **101** exceeds a threshold. For example, if the velocity of wireless communication device **101** exceeds ten miles per hour, packet router **130** would typically select a larger number of output ports to increase the likelihood that wireless communication device **101** will receive the packet.

Once the output ports have been selected, packet router **130** broadcasts the data packet over the plurality of output ports (**206**). Packet router **130** typically broadcasts the data packet by wirelessly propagating the data packet over the plurality of output ports. In some examples, the data packet is broadcast over the plurality of output ports in a plurality of wireless protocols. In examples that consider the velocity of wireless communication device **101**, packet router **130** could broadcast the data packet using the plurality of output ports of the packet router if the packet router serves an area including the location and if the velocity of the wireless communication device exceeds the threshold.

Advantageously, packet router **130** processes the location of wireless communication device **101** to select a plurality of output ports on which to broadcast a data packet to wireless communication device **101**. In this manner, wireless communication device **101** may monitor for data packets that are broadcast by packet router **130**. For example, wireless communication device **101** could identify its MAC address in the data packet, and receive the data packet based on the MAC address. Since packet router **130** may broadcast data packets intended for wireless communication device **101** in a plurality of different wireless protocols, communication sessions between device **101** and communication network **120** may be maintained, even while transitioning across different access media that support the different wireless protocols.

Referring back to FIG. **1**, wireless communication device **101** comprises any device having wireless communication connectivity with hardware and circuitry programmed to function as a telecommunications device, such as Radio Frequency (RF) communication circuitry and an antenna. The RF communication circuitry typically includes an amplifier, filter, modulator, and signal processing circuitry. Wireless communication device **101** may also include a user interface, memory device, software, processing circuitry, or some other communication components. For example, wireless communication device **101** could comprise a telephone, transceiver, mobile phone, cellular phone, smartphone, computer, personal digital assistant (PDA), e-book, game console, mobile Internet device, wireless network interface card, media player, or some other wireless communication apparatus—including combinations thereof. Wireless network protocols that may be utilized by wireless communication device **101** include Code Division Multiple Access (CDMA) 1xRTT, Global System for Mobile communications (GSM), Universal Mobile Telecommunications System (UMTS), High-Speed Packet Access (HSPA), Evolution-Data Optimized (EV-DO), EV-DO rev. A, Third Generation Partnership Project Long Term Evolution (3GPP LTE), Worldwide Interoperability for Microwave Access (WiMAX), IEEE 802.11 protocols (Wi-Fi), Bluetooth, Internet, telephony, or

any other wireless network protocol that facilitates communication between wireless communication device **101** and wireless access node **110**.

Wireless access node **110** comprises RF communication circuitry and an antenna. The RF communication circuitry typically includes an amplifier, filter, RF modulator, and signal processing circuitry. Wireless access node **110** may also comprise a router, server, memory device, software, processing circuitry, cabling, power supply, network communication interface, structural support, or some other communication apparatus. Wireless access node **110** could comprise a base station, Internet access node, telephony service node, wireless data access point, or some other wireless communication system—including combinations thereof. Some examples of wireless access node **110** include a base transceiver station (BTS), base station controller (BSC), radio base station (RBS), Node B, enhanced Node B (eNode B), and others. Wireless network protocols that may be utilized by wireless access node **110** include CDMA, GSM, UMTS, HSPA, EV-DO, EV-DO rev. A, 3GPP LTE, WiMAX, Wi-Fi, Bluetooth, Internet, telephony, or some other communication format—including combinations thereof.

Communication network **120** comprises the core network of a wireless communication provider, and could include routers, gateways, telecommunication switches, servers, processing systems, or other communication equipment and systems for providing communication and data services. Communication network **120** could comprise wireless communication nodes, telephony switches, Internet routers, network gateways, computer systems, communication links, or some other type of communication equipment—including combinations thereof. Communication network **120** may also comprise optical networks, asynchronous transfer mode (ATM) networks, packet networks, radio access networks (RAN), local area networks (LAN), metropolitan area networks (MAN), wide area networks (WAN), or other network topologies, equipment, or systems—including combinations thereof. Communication network **120** may be configured to communicate over metallic, wireless, or optical links. Communication network **120** may be configured to use time-division multiplexing (TDM), Internet Protocol (IP), Ethernet, optical networking, wireless protocols, communication signaling, or some other communication format—including combinations thereof. In some examples, communication network **120** includes further access nodes and associated equipment for providing communication services to many wireless communication devices across a large geographic region.

Packet router **130** comprises a processing system and communication transceiver. Packet router **130** may also include other components such as a router, server, data storage system, and power supply. Packet router **130** may reside in a single device or may be distributed across multiple devices. Packet router **130** may be a discrete system or may be integrated within other systems—including other systems within communication system **100**. In some examples, packet router **130** could comprise a mobile switching center, router, switching system, packet gateway, network gateway system, Internet access node, application server, service node, firewall, or some other communication system—including combinations thereof.

Database **140** comprises a processing system and communication transceiver. Database **140** may also include other components such as a router, server, data storage system, and power supply. Database **140** may reside in a single device or may be distributed across multiple devices. Database **140** may be a discrete system or may be integrated within other systems—including other systems within communication system **100**. In some examples, database **140** could comprise a network database system, network-attached storage, storage area network, home location register, visitor location register, packet gateway, mobile switching center, network gateway system, Internet access node, application server, service node, firewall, or some other communication system—including combinations thereof.

Wireless communication link **111** uses the air or space as the transport medium. Wireless communication link **111** may use various protocols, such as CDMA, GSM, UMTS, HSPA, EV-DO, EV-DO rev. A, 3GPP LTE, WiMAX, Wi-Fi, Bluetooth, Internet, telephony, or some other communication format—including combinations thereof. Wireless communication link **111** may comprise many different signals sharing the same link. For example, wireless communication link **111** could include multiple signals operating in a single propagation path comprising multiple communication sessions, frequencies, timeslots, transportation ports, logical transportation links, network sockets, IP sockets, packets, or communication directions—including combinations thereof.

Communication links **121**, **131**, and **141** use metal, air, space, optical fiber such as glass or plastic, or some other material as the transport media—including combinations thereof. Communication links **121**, **131**, and **141** could use various communication protocols, such as TDM, IP, Ethernet, telephony, optical networking, hybrid fiber coax (HFC), communication signaling, wireless protocols, or some other communication format—including combinations thereof. Communication links **121**, **131**, and **141** may be direct links or could include intermediate networks, systems, or devices.

FIG. **3** is a block diagram that illustrates communication system **300**. Communication system **300** includes wireless communication device **301**, wireless access node **310**, communication network **320**, packet router **330**, wireless device information database **340**, and router port database **350**. Wireless communication device **301** and wireless access node **310** are in communication over wireless communication link **311**. Wireless access node **310** and communication network **320** communicate over communication link **321**. Communication network **320** and wireless device information database **340** are in communication over communication link **341**, while packet router **330** and communication network **320** communicate over communication link **331**. Packet router **330** and router port database **350** are in communication over communication link **351**. Packet router **330** comprises ports A, B, and C, over which packet router **330** may wirelessly transmit data packets. In this example, ports A, B, and C of packet router **330** each communicate using a different wireless protocol. Although wireless device information database **340** and router port database **350** are shown on FIG. **3** as separate databases, the information in each database **340** and **350** could all be related in a single database or some other storage system in some examples. Also, although router port database **350** is shown external to packet router **330**, database **350** could be stored in an internal storage system of packet router **330** in some examples.

FIG. **4** illustrates tables in wireless device information database **340** and router port database **350** in an exemplary embodiment. The table shown in wireless device information database **340** includes columns labeled IP ADDRESS, MAC ADDRESS, and GPS. Each row in the table represents related data, such that the values in the MAC ADDRESS and GPS fields are associated with the IP ADDRESS from the corresponding row. Typically, the values in wireless device information table **340** are populated by wireless communication devices, such as wireless communication device **301**, that

transmit the data for delivery to wireless device information database **340**. Thus, the four rows shown in wireless device information database **340** represent four different wireless communication devices at different locations, as indicated by the GPS ranges for each of the IP and MAC address pairs. One of skill in the art will understand that the GPS ranges in the GPS field would typically comprise actual values of GPS coordinates or other position information, but are referred to herein simply as RANGE 1 though RANGE 4 for clarity. The information in wireless device information database **340** is utilized by packet router **330** to assist in routing packets to the wireless communication devices identified in database **340**.

The table shown in router port database **350** comprises two columns labeled GPS and ROUTER PORTS. Thus, in this example, the table in router port database **350** maps GPS ranges to router ports of packet router **330**. The GPS field shown in router port database **350** typically corresponds to the GPS field in wireless device information database **340**, so that a GPS range received by querying wireless device information database **340** can be used to query router port database **350** to determine the appropriate router ports of packet router **330** on which to broadcast a packet. Note that GPS ranges 2, 3, and 4 are associated with multiple ports of packet router **330**: B+C, A+C, and A+B+C, respectively. It should be understood that although the tables shown in databases **340** and **350** on FIG. **4** only comprise four rows each in this example, the number of rows of information in these tables would typically be much greater.

FIG. **5** is a sequence diagram that illustrates an operation of communication system **300** in an exemplary embodiment. Prior to the steps shown on FIG. **5**, wireless communication device **301** has acquired an IP address from communication network **320** and has determined its current location by utilizing GPS satellites. To begin, wireless communication device **301** transmits its IP address, MAC address, and a GPS range indicating the current location of device **301** for delivery to wireless device information database **340**. In this example, wireless communication device **301** has an IP address of 64.173.211.241, a MAC address of 00:1D:FE:22:B2:DF, and a GPS of "RANGE 3", which corresponds to the third row down in the table of wireless device information database **340** as shown in FIG. **4**. Thus, this information is provided by wireless communication device **301** and entered into wireless device information database **340**, as shown in FIG. **5**.

After the database **340** has been updated with the information from wireless communication device **301**, packet router **330** receives a data packet with a destination address corresponding to the IP address of device **301**. Packet router **330** therefore queries wireless device information database **340** with the destination IP address of the received packet to determine the MAC address and GPS range associated with this IP address. Wireless device information database **340** responds to the query with the MAC address and GPS range that are stored therein for wireless communication device **301** based on the IP address in the query. Once packet router **330** receives the MAC address and GPS range for wireless communication device **301**, packet router **330** queries router port database **350** with the GPS range received from wireless device information database **340**. As discussed above, the GPS range in this case is "RANGE 3", so when packet router **330** queries router port database **350** with this GPS range, router port database **350** returns router ports A and C to packet router **330**, as shown in the table of router port database **350** in FIG. **4**.

Once packet router **330** receives a response from router port database **350** indicating that router ports A and C correspond to the GPS "RANGE 3", packet router **330** broadcasts the data packet over both ports A and C with the MAC address for wireless communication device **301**. The MAC address for device **301** was previously received by packet router **330** in response to the query to wireless device information database **340**. Packet router **330** broadcasts the data packet with the MAC address for wireless communication device **301** to enable device **301** to detect the packets intended for it based on its MAC address. Thus, wireless communication device **301** is configured to listen for data packets having this MAC address on all wireless networks that are in communication with device **301**. In this example, router port A communicates over a third generation (3G) CDMA wireless network, while router port C communicates over a fourth generation (4G) WiMAX wireless network, and wireless communication device **301** is a dual-mode 3G/4G device. Thus, wireless communication device **301** is configured to identify data packets having its MAC address on both the 3G CDMA network and the 4G WiMAX network in this example. Note that although wireless communication device is only shown in FIG. **5** as listening for packets with its MAC address at the time packet router **330** broadcasts the packet, device **301** would typically be configured to continually listen for packets with its MAC address at all times.

Although packet router **330** broadcasts the data packet simultaneously over both ports A and C, wireless communication device **301** first receives the data packet over the 4G WiMAX wireless network via port C of packet router **330**. Subsequently, wireless communication device **301** receives the same packet from packet router **330** over the 3G CDMA wireless network via port A. In this example, wireless communication device **301** is configured to determine whether any data packets received have already been received over a different access medium. Therefore, wireless communication device **301** processes the two packets and determines that the packet received over the 3G CDMA wireless network was already received by device **301** over the 4G WiMAX network. Thus, wireless communication device **301** discards the duplicate packet and presents only one copy of the packet to the network layer (layer **3**) interface of device **301**. In this manner, wireless communication device **301** may receive packets over a plurality of wireless access media as device **301** transitions between them. The received packets are processed to ensure that any duplicate packets are discarded, and the packets are then transparently presented to the layer **3** network layer of device **301**, so that the layer **3** interface of device **301** is unaware over which wireless network or networks the packets were received.

In some examples, packet router **330** could be configured to broadcast data packets over multiple router ports only when the packet is in the proximity of its target destination. This proximity determination could be based on comparing the location of wireless communication device **301** to threshold values. For example, if wireless communication device **301** is currently located in a geographic area served by a different router than packet router **330**, packet router **330** would simply forward packets to the router that is currently serving device **301** based on the GPS range or other location information in the wireless device information database **340**. When the router that is serving the area in which wireless communication device **301** is located receives the packets from packet router **330**, that router could query wireless device information database **340** to determine that the location of device **301** is within a proximity threshold, and would therefore broadcast the packets over the ports indicated in its router port database. Effectively, as packets near their destination, a packet router that is closer to the target device will

tend to broadcast the packets over a greater number of ports than a router that is farther away from the destination.

FIG. **6** is a block diagram that illustrates packet router **600**. Packet router **600** provides an example of packet routers **130** and **330**, although routers **130** and **330** may use alternative configurations. Packet router **600** comprises communication transceiver **601** and processing system **603**. Processing system **603** is linked to communication transceiver **601**. Processing system **603** includes processing circuitry **605** and memory device **606** that stores operating software **607**.

Communication transceiver **601** comprises components that communicate over communication links, such as network cards, ports, RF transceivers, processing circuitry and software, or some other communication components. Communication transceiver **601** may be configured to communicate over metallic, wireless, or optical links. Communication transceiver **601** may be configured to use TDM, IP, Ethernet, optical networking, wireless protocols, communication signaling, or some other communication format—including combinations thereof. In some examples, communication transceiver **601** could be configured to receive a data packet with a destination address of a packet address assigned to a wireless communication device, and broadcast a data packet over a plurality of output ports.

Processing circuitry **605** comprises microprocessor and other circuitry that retrieves and executes operating software **607** from memory device **606**. Memory device **606** comprises a disk drive, flash drive, data storage circuitry, or some other memory apparatus. Operating software **607** comprises computer programs, firmware, or some other form of machine-readable processing instructions. Operating software **607** may include an operating system, utilities, drivers, network interfaces, applications, or some other type of software.

When executed by circuitry **605**, operating software **607** directs processing system **603** to operate as described herein for packet router **130**. In particular, operating software **607** may direct processing system **603** to direct communication transceiver **601** to receive a data packet with a destination address of a packet address assigned to a wireless communication device. In addition, operating software **607** directs processing system **603** to query a database with the packet address to determine a device identifier and a location of the wireless communication device, and process the location to select a plurality of output ports of packet router **600**. Further, operating software **607** may direct processing system **603** to direct communication transceiver **601** to broadcast the data packet over the plurality of output ports.

In some examples, operating software **607** could comprise a packet receiver software module that receives a data packet with a destination address of a packet address assigned to a wireless communication device. Additionally, operating software **607** could comprise a port selection software module that queries a database with the packet address to determine a device identifier and a location of the wireless communication device, and process the location to select a plurality of output ports of packet router **600**. Further, operating software **607** could comprise a packet broadcast software module that broadcasts a data packet over the plurality of output ports.

FIG. **7** is a block diagram that illustrates wireless communication device **700**. Wireless communication device **700** provides an example of wireless communication devices **101** and **301**, although devices **101** and **301** could use alternative configurations. Wireless communication device **700** comprises wireless communication transceiver **701**, processing system **702**, and user interface **703**. Processing system **702** is linked to wireless communication transceiver **701** and user interface **703**. Processing system **702** includes processing circuitry **704** and memory device **705** that stores operating software **706**. Wireless communication device **700** may include other well-known components such as a battery and enclosure that are not shown for clarity. Wireless communication device **700** may comprise a telephone, computer, e-book, mobile Internet appliance, media player, game console, wireless network interface card, or some other wireless communication apparatus—including combinations thereof.

Wireless communication transceiver **701** comprises RF communication circuitry and an antenna. The RF communication circuitry typically includes an amplifier, filter, RF modulator, and signal processing circuitry. Wireless communication transceiver **701** may also include a memory device, software, processing circuitry, or some other communication device. Wireless communication transceiver **701** may use various protocols, such as CDMA, GSM, UMTS, HSPA, EV-DO, EV-DO rev. A, 3GPP LTE, WiMAX, Wi-Fi, Bluetooth, Internet, telephony, or some other wireless communication format. Wireless communication transceiver **701** could be configured to acquire a packet address from a communication network, wherein the communication network assigns the packet address to the wireless communication device **700**, and transmit the packet address, a device identifier, and a location of the wireless communication device **700** for delivery to a database in the communication network.

User interface **703** comprises components that interact with a user to receive user inputs and to present media and/or information. User interface **703** may include a speaker, microphone, buttons, lights, display screen, touch screen, touch pad, scroll wheel, communication port, or some other user input/output apparatus—including combinations thereof. User interface **703** may be omitted in some examples.

Processing circuitry **704** comprises microprocessor and other circuitry that retrieves and executes operating software **706** from memory device **705**. Memory device **705** comprises a disk drive, flash drive, data storage circuitry, or some other memory apparatus. Processing circuitry **704** is typically mounted on a circuit board that may also hold memory device **705** and portions of communication transceiver **701** and user interface **703**. Operating software **706** comprises computer programs, firmware, or some other form of machine-readable processing instructions. Operating software **706** may include an operating system, utilities, drivers, network interfaces, applications, or some other type of software. When executed by processing circuitry **704**, operating software **706** directs processing system **702** to operate wireless communication device **700** as described herein for wireless communication devices **101** and **301**. In particular, operating software **706** directs processing system **702** to direct wireless communication transceiver **701** to acquire a packet address from a communication network, wherein the communication network assigns the packet address to the wireless communication device **700**, and transmit the packet address, a device identifier, and a location of the wireless communication device **700** for delivery to a database in the communication network. In some examples, operating software **706** could comprise a database update software module that transmits a packet address, a device identifier, and a location of the wireless communication device **700** for delivery to a database in a communication network. Further, in some examples, operating software **706** could direct processing system **702** identify a media access control address in a data packet, and direct wireless communication transceiver **701** to receive the data packet based on the media access control address.

The above description and associated figures teach the best mode of the invention. The following claims specify the scope of the invention. Note that some aspects of the best mode may

not fall within the scope of the invention as specified by the claims. Those skilled in the art will appreciate that the features described above can be combined in various ways to form multiple variations of the invention. As a result, the invention is not limited to the specific embodiments described above, but only by the following claims and their equivalents.

What is claimed is:

1. A method of operating a communication system, the method comprising:

in a wireless communication device, acquiring a packet address from a communication network, wherein the communication network assigns the packet address to the wireless communication device;

in the wireless communication device, transmitting the packet address, a device identifier, and a geographic location of the wireless communication device for delivery to a database in the communication network;

in a packet router, receiving a data packet with a destination address of the packet address assigned to the wireless communication device, and querying the database with the packet address to determine the device identifier and the geographic location of the wireless communication device;

in the packet router, processing the geographic location to select a plurality of output ports of the packet router; and

in the packet router, broadcasting the data packet over the plurality of output ports.

2. The method of claim **1** wherein the packet router serves an area including the location.

3. The method of claim **1** wherein broadcasting the data packet over the plurality of output ports comprises broadcasting the data packet by wirelessly propagating the data packet over the plurality of output ports.

4. The method of claim **1** wherein each output port of the plurality of output ports communicates using a different wireless protocol of a plurality of wireless protocols.

5. The method of claim **1** wherein the device identifier comprises a media access control address.

6. The method of claim **5** further comprising, in the wireless communication device, identifying the media access control address in the data packet, and receiving the data packet based on the media access control address.

7. The method of claim **1** wherein the location is identified by a global positioning system range.

8. The method of claim **1** wherein processing the location to select a plurality of output ports of the packet router comprises determining a velocity of the wireless communication device, and determining if the velocity of the wireless communication device exceeds a threshold.

9. The method of claim **8** wherein broadcasting the data packet over the plurality of output ports comprises broadcasting the data packet using the plurality of output ports of the packet router if the packet router serves an area including the location and if the velocity of the wireless communication device exceeds the threshold.

10. The method of claim **8** wherein determining if the velocity of the wireless communication device exceeds the threshold comprises determining the velocity of the wireless communication device based on a series of location updates associated with the wireless communication device and timestamps corresponding to the location updates, and comparing the velocity to the threshold.

11. A communication system comprising:

a wireless communication device configured to acquire a packet address from a communication network, wherein the communication network assigns the packet address to the wireless communication device, and transmit the packet address, a device identifier, and a location of the wireless communication device for delivery to a database in the communication network; and

a packet router configured to receive a data packet with a destination address of the packet address assigned to the wireless communication device, query the database with the packet address to determine the device identifier and the location of the wireless communication device, process the location to select a plurality of output ports of the packet router, and broadcast the data packet over the plurality of output ports.

12. The system of claim **11** wherein the packet router serves an area including the location.

13. The system of claim **11** wherein the packet router configured to broadcast the data packet over the plurality of output ports comprises the packet router configured to wirelessly propagate the data packet over the plurality of output ports.

14. The system of claim **11** wherein each output port of the plurality of output ports communicates using a different wireless protocol of a plurality of wireless protocols.

15. The system of claim **11** wherein the device identifier comprises a media access control address.

16. The system of claim **15** further comprising the wireless communication device configured to identify the media access control address in the data packet, and receive the data packet based on the media access control address.

17. The system of claim **11** wherein the location is identified by a global positioning system range.

18. The system of claim **11** wherein the packet router configured to process the location to select a plurality of output ports of the packet router comprises the packet router configured to determine a velocity of the wireless communication device, and determine if the velocity of the wireless communication device exceeds a threshold.

19. The system of claim **18** wherein the packet router configured to broadcast the data packet over the plurality of output ports comprises the packet router configured to broadcast the data packet using the plurality of output ports of the packet router if the packet router serves an area including the location and if the velocity of the wireless communication device exceeds the threshold.

20. A method of operating a communication system, the method comprising:

in a wireless communication device, transmitting a packet address, a media access control address, and a location of the wireless communication device for delivery to a database in a communication network;

in a packet router, receiving a data packet with a destination address of the packet address assigned to the wireless communication device, and querying the database with the packet address to determine the media access control address and the location of the wireless communication device;

in the packet router, processing the location to select a plurality of output ports of the packet router, wherein each output port of the plurality of output ports communicates using a different wireless protocol of a plurality of wireless protocols;

in the packet router, broadcasting the data packet over the plurality of output ports; and

in the wireless communication device, identifying the media access control address in the data packet, and receiving the data packet based on the media access control address.

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