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(54) Title: LAYERED PROTOCOL STACK FOR WIRELESS COMMUNICATION

(57) Abstract: The invention relates to a method and system for a data collection system that collects and processes telemetry data received from remote locations. The disclosed system and method includes a plurality of instruments configured to transmit the telemetry data to a coordinator module through a wireless communication module. The wireless communication module supports a layered protocol architecture. The layered protocol architecture has a physical layer supporting wired and wireless transmission, a MAC layer, a network layer supporting a mesh and star network; and an application layer supporting a plurality of applications. The disclosed system and method further includes a plurality of coordinator modules and a processing module. The coordinator modules are configured to receive the telemetry data from the plurality of instruments through the wireless communication module. The processing module is configured to receive the telemetry data from the coordinator module and process the telemetry data.

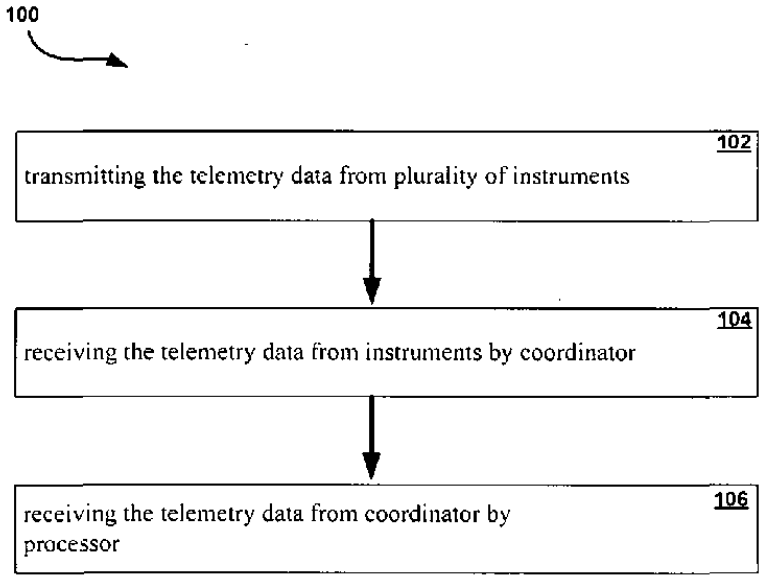

Figure 1

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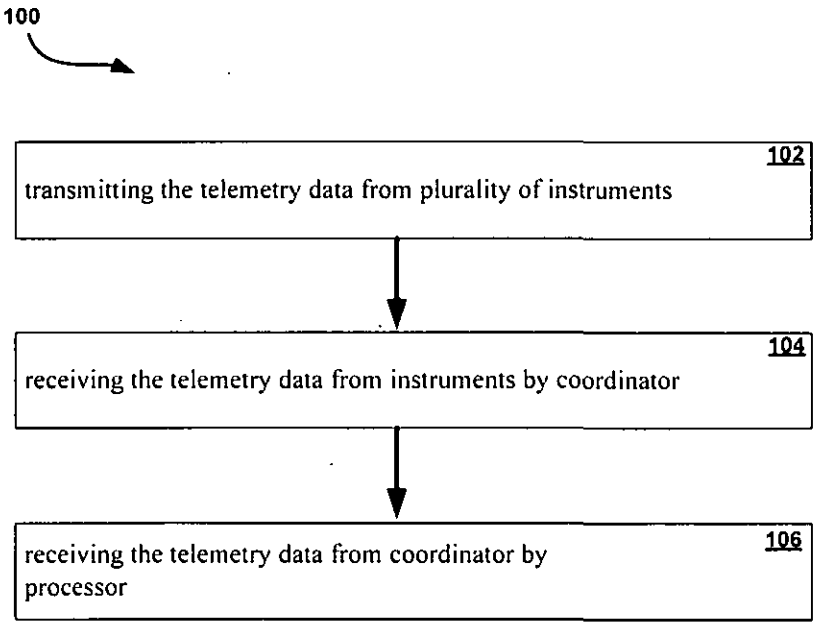
ABSTRACT

LAYERED PROTOCOL STACK FOR WIRELESS COMMUNICATION

The invention relates to a method and system for a data collection system that collects and processes telemetry data received from remote locations. The disclosed system and method includes a plurality of instruments configured to transmit the telemetry data to a coordinator module through a wireless communication module. The wireless communication module supports a layered protocol architecture. The layered protocol architecture has a physical layer supporting wired and wireless transmission, a MAC layer, a network layer supporting a mesh and star network; and an application layer supporting a plurality of applications. The disclosed system and method further includes a plurality of coordinator modules and a processing module. The coordinator modules are configured to receive the telemetry data from the plurality of instruments through the wireless communication module. The processing module is configured to receive the telemetry data from the coordinator module and process the telemetry data.



18-Jan-2018/3864/2017410019 80/Abstract

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We Claim:

1. A data collection system that collects and processes telemetry data received from remote locations, the data collection system comprising:

a plurality of instruments configured to transmit the telemetry data through a wireless communication module, wherein the wireless communication module supporting a layered protocol architecture having at least:

a physical layer supporting wired and wireless transmission;

a MAC layer;

a network layer supporting a mesh and star network; and

an application layer supporting a plurality of applications;

a plurality of coordinator modules configured to receive the telemetry data from the plurality of instruments through the wireless communication module; and

a processing module configured to receive the telemetry data from the plurality of coordinator modules and process the telemetry data.

2. The system as claimed in claim 1, wherein the plurality of instruments are measuring instruments.

3. The system as claimed in claim 2, wherein the measuring instrument is a water meter, gas meter or electricity meter.

4. The system as claimed in claim1, further comprising the plurality of coordinator modules connect and manage a plurality of measuring instruments via 2.4 GHz 866 MHz wireless bandwidth.

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5. The system as claimed in claim1, wherein the processing module is a computer or any other external device connected to a data repository.

6. The system as claimed in claim1, wherein the communication between the coordinator module and the processing module is serial communication.

7. The system as claimed in claim 5, wherein the computer provides a telemetry data access interface to a user.

8. The system as claimed in claim 1, further comprising generating reports from the stored telemetry data.

9. The system as claimed in claim 1, wherein the data collection system is an automatic meter reading system.

10. The system as claimed in claim 1, wherein the layered protocol architecture supports manual and automatic network formation of the plurality of instruments.

Dated this 18th day of January 2017

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FIELD OF INVENTION

The invention generally relates to system and methods for data collection from remote locations and more particularly to an automated data collection system which collects data from instruments, and processes and stores the data for routing to end users and business systems.

BACKGROUND

Mesh Network is a group of two or more devices linked together and consists of different nodes with a single master where the data is exchanged in the form of packets. The mesh network extends the connectivity area of the devices beyond the limited range of a single access point. The mesh network is characterized by dynamic self-organization, self-configuration and self-healing to enable quick deployment, easy maintenance, low cost, high scalability and reliable services, as well as enhancing network capacity, connectivity and resilience. The mesh network typically employs a wireless mesh protocol.

The wireless mesh protocol creates a network of objects that can communicate with each other and can get connected to the internet using a Low Power Radio. As the world is trying to connect each "Things" to the internet, the importance of wireless mesh network is very high. Some exemplary Mesh Networking solutions are ZigBee and 6LowPan. However, the known Mesh Networking solutions have various limitations such as, but not limited to, modification of the data format to support respective protocols (Zigbee, 6LowPan), stability, restricted band usage, security, etc. Typically known Mesh Networking solutions are stable only in well planned cities. A small disruption in the network may destabilize whole network. Known wireless solutions are mostly developed for restricted band usage, for example ZigBee protocol

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is mainly developed on 2.4 GHz band, resulting in less line of sight communication range. Moreover known solutions have security issues since at time the data packet can be analysed by any third party.

Hence, there is a need to have an improved wireless mesh system that can be interfaced to any of the existing data collection instruments without any source code modification and where there is complete control over the network formation so that it may be implemented in any geographical conditions.

SUMMARY OF THE INVENTION

Exemplary embodiments of the invention disclose a data collection system that collects and processes telemetry data received from remote locations. According to an exemplary embodiment, the disclosed system includes a plurality of instruments configured to transmit the telemetry data to a coordinator module through a wireless communication module. The wireless communication module supports a layered protocol architecture. The layered protocol architecture has a physical layer supporting wired and wireless transmission, a MAC layer, a network layer supporting a mesh and star network; and an application layer supporting a plurality of applications. The system further includes a plurality of coordinator modules and a processing module. The coordinator modules are configured to receive the telemetry data from the plurality of instruments through the wireless communication module. The processing module is configured to receive the telemetry data from the coordinator module and process the telemetry data.

BRIEF DESCRIPTION OF DRAWINGS

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Other objects, features, and advantages of the invention will be apparent from the following description when read with reference to the accompanying drawings. In the drawings, wherein like reference numerals denote corresponding parts throughout the several views:

Figure 1 illustrates a block diagram of a process for collecting and processing telemetry data received from remote locations, according to an exemplary embodiment of the invention;

Figure 2 illustrates an exemplary data collection system using a mesh network;

Figure 3 illustrates an exemplary data collection system using a star network; and

Figure 4 illustrates a layered protocol architecture; and

Figure 5 illustrates a packet header format.

DETAILED DESCRIPTION OF DRAWINGS

The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of exemplary embodiments of the invention as defined by the claims and their equivalents. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the invention. In addition, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

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According to embodiments of the invention, a system and method for providing a data collection system that collects and processes telemetry data received from remote locations is disclosed.

FIG. 1 illustrates a block diagram of the process 100 for collecting and processing telemetry data received from remote locations in a wireless network, according to an embodiment of the invention. As illustrated, at step 102, the telemetry data may be transmitted from a plurality of instruments such as, but not limited to, water meter, gas meter or electricity meter, weighing machines, electronic data recorders, thermometers etc in the wireless network. According to exemplary embodiment, the wireless network may be a mesh network or a star network. At step 104, the telemetry data may be received from the plurality of instruments by one or more coordinators. The terms coordinator and master may be used interchangeably in various embodiments. According to an embodiment, one or more of the instruments in the wireless network may be coordinator. At step 106, the telemetry data may be received from the one or more coordinators by a processor. According to an embodiment, the processor may process and store the telemetry data for routing to an end user(s) and/or to a business system(s).

FIG. 2 illustrates an exemplary data collection system that collects and processes telemetry data received from remote locations, according to one embodiment of the present invention. According to an exemplary embodiment, the data collection system may be an automatic meter reading system. The disclosed system 200 may include a plurality of instruments, a plurality of coordinator modules 212 and a processing module 214. The system 200 may include a plurality of instruments 202, 204, 206, 208, and 210. According to an embodiment, the plurality of instruments may be measuring instruments such as, but not limited to, water meter, gas meter or electricity meter, weighing machines, electronic data recorders. According to an

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embodiment, the plurality of instruments 202, 204, 206, 208 and 210 may be configured to transmit the telemetry data to a coordinator module. According to an embodiment, the plurality of instruments may be connected to each other and to the coordinator module through a mesh network. According to an embodiment, one or more of the instrument in the wireless network may be coordinator.

According to another embodiment illustrated in Figure 3, the plurality of instruments may be connected to the coordinator module through a star network. According to an embodiment, the system 200 may include one or more coordinator modules. According to another embodiment, one instrument may be connected to one coordinator module. The transmission of the telemetry data to the one or more coordinator modules may be through a wireless communication module. According to another embodiment, the wireless communication module may support a layered protocol architecture.

Figure 4 illustrates an exemplary layered protocol architecture having a physical layer 402, a MAC layer 404, a network layer 406 and an application layer 408. The physical layer 402 may support wired and wireless communication. The physical layer may handle features including activation and deactivation of radio transceiver, power level detection within current channel, received signal strength indication for received packets, channel frequency selection and data transmission and reception. According to an embodiment, a user may configure a type of physical media required for communication. According to an exemplary embodiment, the user may use AT command to select the mode of communication. According to an exemplary embodiment, ATCOMMODE XY command may be used to select the mode of communication. According to another embodiment, the physical layer supports 866 MHz, 2.4 GHz and RS485 bandwidth. According to yet another embodiment, the user may connect the

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device (device loaded with protocol stack) to PC using a serial interface. The user may enter one or more commands from hyper terminal or any other application that supports serial communication.

The MAC layer 404 may describe the different devices used in the protocol and procedure to manage different frames. The functionalities of MAC layer may include managing coordinator, slave device, repeater and hand held unit (HHU), performing Automatic Close in reception Detection and Control (ACDC) to avoid data loss due to closely packed devices, supporting commissioning process, managing different frames and device addressing.

The MAC layer may support commissioning. According to an embodiment, the commissioning may be used for manual network formation when there is no predefined arrangement for node devices. Commissioning is the process of configuring nodes in the network to enable communication to the coordinator directly or through other nodes. According to an embodiment, the node may be a slave device or a repeater. Network path may be constructed based on the best received signal strength indication (RSSI) values. According to an embodiment, if RSSI is greater than or equal to a predefined value, then the nodes may communicate with each other.

The network and security layer 406 may define the algorithms used for network formation and method of maintaining the network. The functionalities of the network layer may include forming mesh or star network, maintaining mesh network, dynamic self-curing, commands to sync with the device and encrypting the data.

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In automatic network formation, the network formation occurs at a faster rate. According to an exemplary embodiment, time taken may be less than 50 seconds to form a network of 50 nodes. According to an embodiment, the best path in the network may be selected based on a combination of signal strength algorithm and shortest path algorithm. In the automatic network formation mode, each slave device may send ping messages at a predefined interval. Each of the slave devices that receive the ping message from the neighbouring slave devices updates respective slave device's network table. The slave devices may be arranged on the basis of RSSI value in the network table. The network tables of the slave devices may be periodically refreshed. According to an embodiment, the coordinator may update entire network information of the slave devices on the coordinator's network table.

According to an embodiment, the network layer may support manual and automatic network formation of the plurality of instruments. According to another embodiment, commands may be entered by a user through an interface to choose manual or automatic network formation method. According to yet another embodiment, the user may select network formation method using AT command. According to an exemplary embodiment, user may use ATNETFORMTYPE XY command to select network formation. According to yet another embodiment, user may connect his device (device loaded with protocol stack) to PC using a serial interface. The user may enter one or more commands from hyper terminal or any other application which supports serial communication.

According to another embodiment, the network layer may support a mesh and a star network topology. According to another embodiment, the user may select network topology using AT command. According to an exemplary embodiment, the user may use ATNETTYPE XY command to select network topology. According to yet another embodiment, the user may

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connect his device (device loaded with protocol stack) to PC using a serial interface. The user may enter one or more commands from hyper terminal or any other application which supports serial communication.

According to an embodiment, the wireless communication network may interface with four different types of devices namely coordinator, slave, repeater and Hand Held Unit (HHU). The wireless communication protocol may support eight different frequency channels (866 MHz) where one channel may accommodate 250 devices. The coordinator node may initiate communication with slave nodes and repeaters. According to an embodiment, the coordinator may be connected to a data concentration unit (DCU). The slave device stores information of the neighbouring nodes (slave device or repeater). The repeater acts as a transparent link to boost signals between two devices. The range issue in remote areas may be addressed by using repeaters.

According to another embodiment, the wireless communication network may support dynamic self-curing in case of network failure. The dynamic self-curing method is a process of configuring the nodes in the network so that the nodes can communicate to the master directly or through other nodes using different paths if the current path fails. The nodes may be updated with multiple paths to communicate with the master based on the RSSI. A network table of each slave device may contain immediate nodes and number of hops required for each of the immediate nodes to reach the master. If the current path to reach the master is failed, then an alternate path may be chosen based on a minimal number of hops.

The application layer 408 may contain rules to establish communication with instruments. The application layer may be modified to support any new application. The functionalities of the

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application layer may include handshaking with the instruments and data collection commands. According to an exemplary embodiment, the application layer may support automated meter reading, industrial automation, smart home applications and wireless avionics intra-communication (WAIC). WAIC is radio communication between two or more points inside a single aircraft. . According to an exemplary embodiment, use of layered protocol architecture in the WAIC reduces the aircraft weight by replacing lengthy wires and cables.

Figure 5 describes a packet header format of the wireless communication protocol according to an embodiment of the invention.

Path Destination Address: - Next immediate path when there are number of nodes between source and destination.

Main Destination Address: - Address from which the data has to be collected.

Main Source Address: - Address to which the data has to be transferred.

Router path [0]:- First hop address through which the source is communicating to the destination.

Router path [1]:- Second hop address through which the source is communicating to the destination.

Router path [2]:- Third hop address through which the source is communicating to the destination.

Packet Type: - Type of packet indicates the type of data.

Packet Number: - Indicates the packet number when there is more than one packet for same data

Network Address: - Current channel number in which the source and destination should communicate.

Route Number: - Route number in which the source and destination is communicating.

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Length of Packet: - Total length of the packet received/sent.

Checksum: - Checksum of the packet header.

Payload is attached to the packet header and the data is sent over the air

According to an embodiment, the plurality of coordinator modules may be configured to receive the telemetry data from the plurality of instruments through the wireless communication module.

The processing module may be configured to receive the telemetry data from the coordinator module and process the telemetry data. According to an embodiment, the processing module may be a computer or other external device connected to a data repository. According to another embodiment, the computer may provide a telemetry data access interface to a user. According to another embodiment, the communication between the coordinator module and the processing module may be serial communication. According to yet another embodiment, the processing module may process the stored telemetry data to generate reports.

The main advantages of the layered protocol architecture are as follows:

The layered protocol architecture may be made compatible with any application. Only the application layer needs to be modified for enabling compatibility. The Commissioning process enables the protocol to support any geographical area. The hand held device helps the user to select best node based on RSSI value. The protocol stack may be modified. The data packets cannot be decoded thereby increasing security. The protocol may be integrated to any existing device without modifying the device source code. The physical layer supports various frequency bands, such as 2.4 GHz, 866 MHz ISM band etc. The disclosed protocol may support clear channel assessment for CSMA/CD which reduces data loss due to interference.

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In the drawings and specification there has been set forth preferred embodiments of the invention, and although specific terms are employed, these are used in a generic and descriptive sense only and not for purposes of limitation. Changes in the form and the proportion of parts, as well as in the substitution of equivalents, are contemplated as circumstances may suggest or render expedient without departing from the spirit or scope of the invention.

Throughout the various contexts described in this disclosure, the embodiments of the invention further encompass computer apparatus, computing systems and machine-readable media configured to carry out the foregoing systems and methods. In addition to an embodiment consisting of specifically designed integrated circuits or other electronics, the present invention may be conveniently implemented using a conventional general purpose or a specialized digital computer or microprocessor programmed according to the teachings of the present disclosure, as will be apparent to those skilled in the computer art.

Appropriate software coding can readily be prepared by skilled programmers based on the teachings of the present disclosure, as will be apparent to those skilled in the software art. The invention may also be implemented by the preparation of application specific integrated circuits or by interconnecting an appropriate network of conventional component circuits, as will be readily apparent to those skilled in the art.

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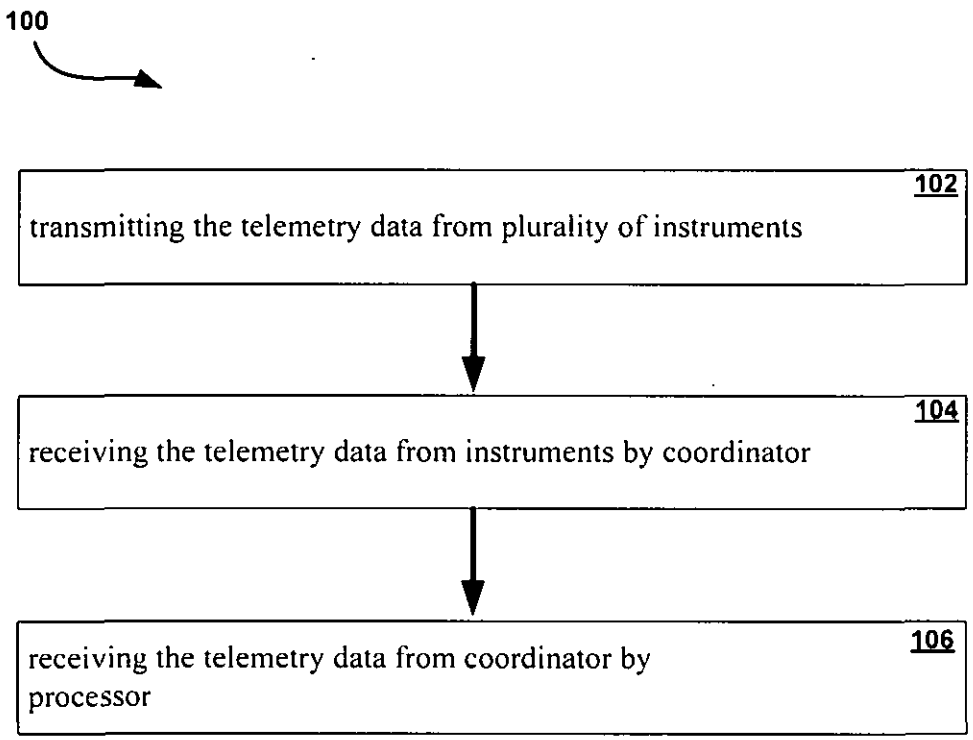

Figure 1

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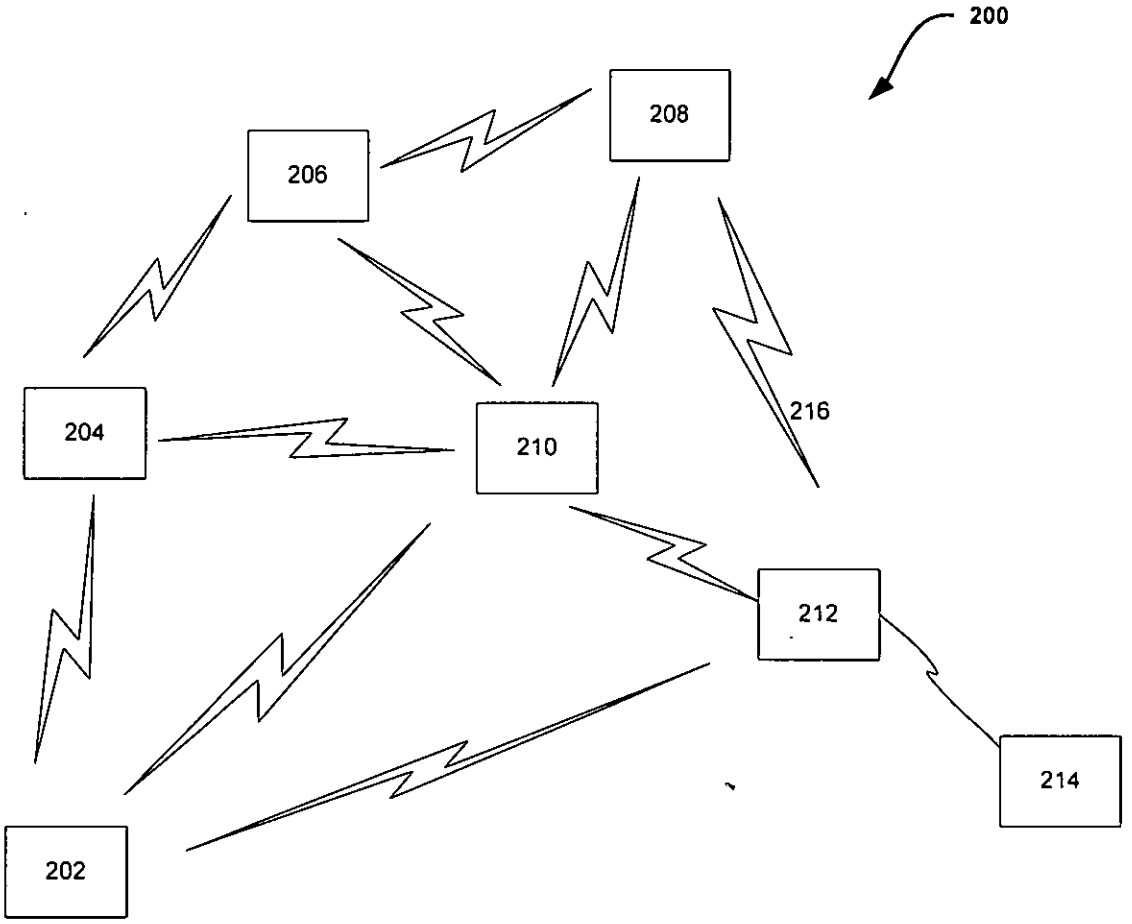

Figure 2

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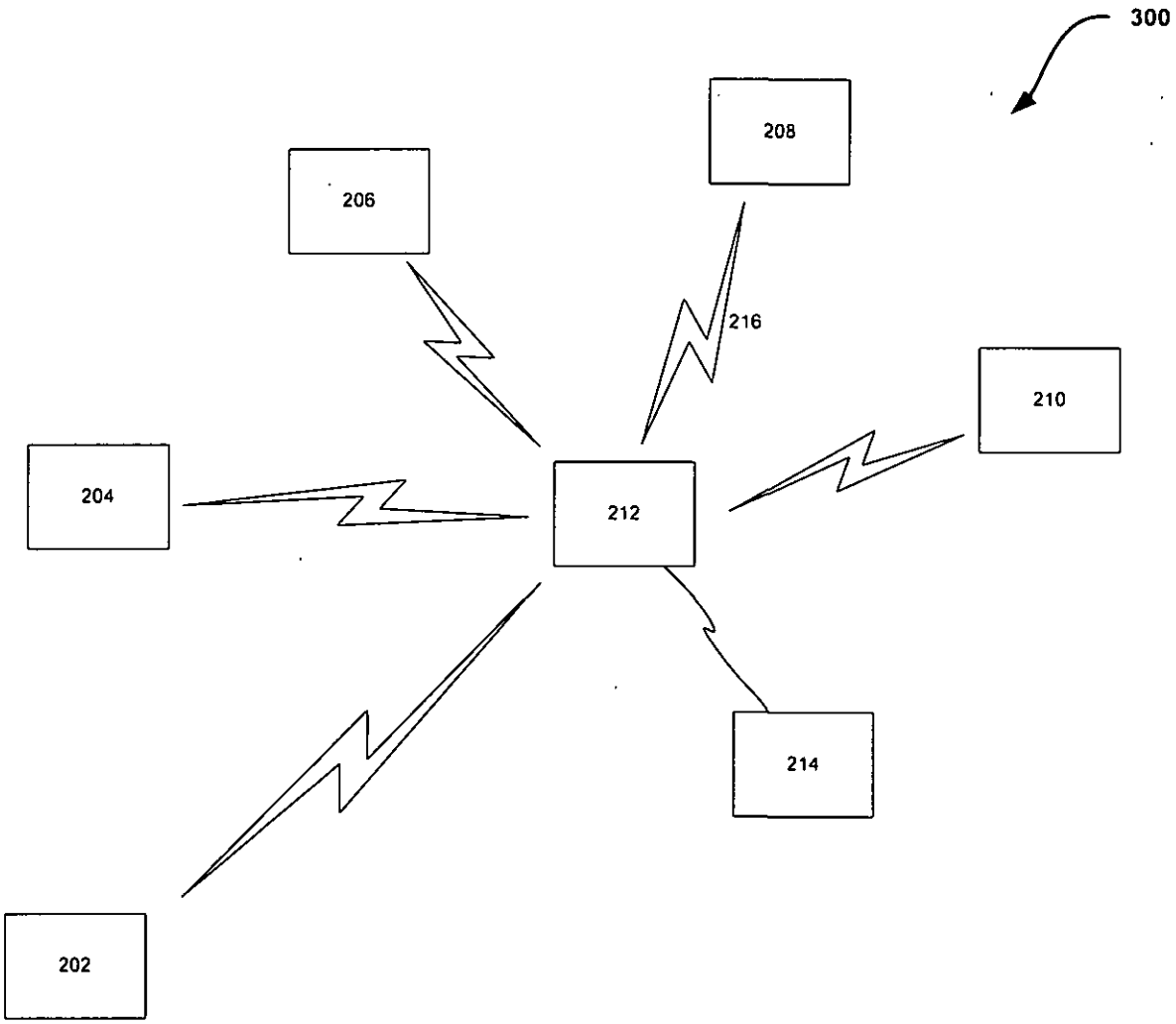

Figure 3

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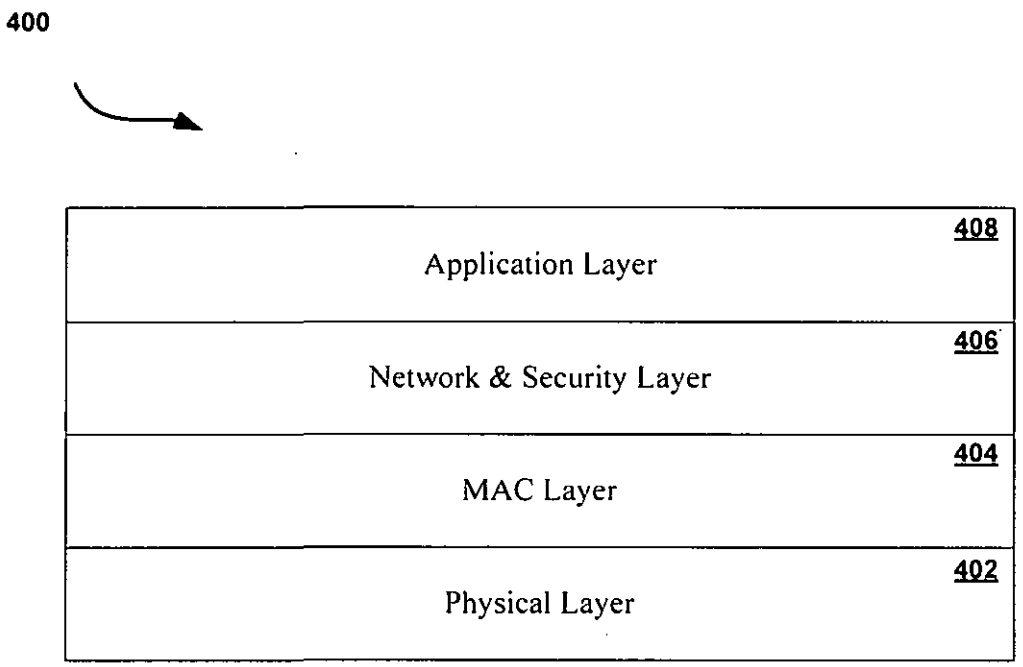

Figure 4

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Path Destination Address	Main Destination Address	Main Source Address	Router path0	Router path1	Router path2	Packet type	Packet number	Network Address	Route number	Length of packet	Checksum

Figure 5

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