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(54) **APPARATUS FOR CONTROLLING MULTI-MODE RADIO ACCESS AND METHOD FOR THE SAME**

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H04Q 7/00 (2006.01)

(52) **U.S. Cl.** **370/331; 370/332; 370/333; 370/338;**
370/348; 455/452.2; 455/422.1; 455/436;
455/438

(58) **Field of Classification Search** **370/331,**
370/332, 338, 348

See application file for complete search history.

ABSTRACT

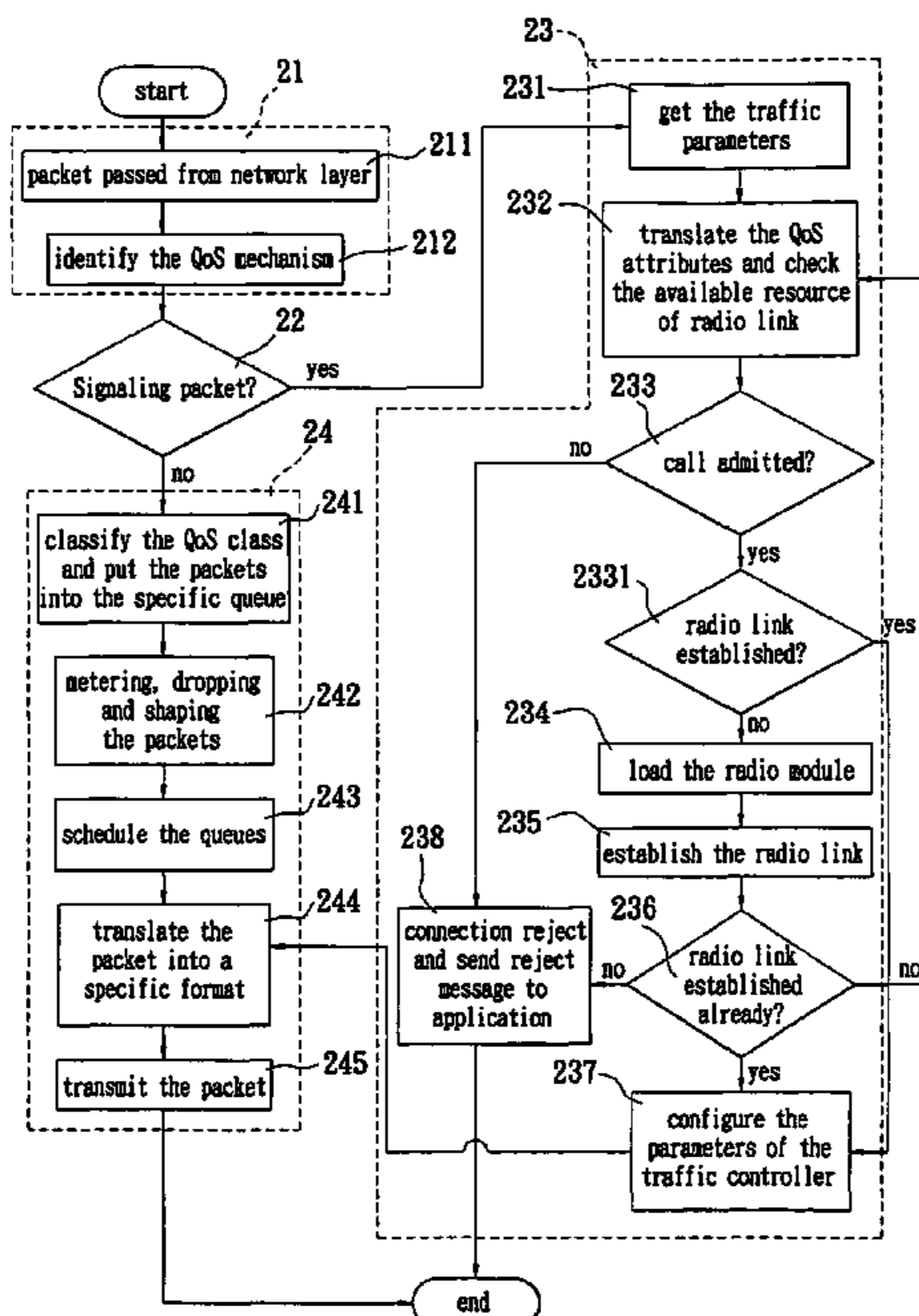
A method and apparatus for controlling multi-mode radio access, more particularly, to a method and apparatus that supports multi-mode reconfigurable, quality of service (QoS) and seamless handoff in different radio systems so as to provide wire-line like QoS guarantee. The apparatus includes a network layer, a radio adaptation layer, a radio system layer and a physical layer. Therein, the radio adaptation layer is used to control the radio modules disposed in the radio system layer to support the QoS needed in the upper layer. The radio adaptation layer is also used to build up, correct and seamlessly change the radio link, and ensures that the packets from the upper layers can be orderly delivered to the lower layer with preset QoS.

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49 Claims, 11 Drawing Sheets



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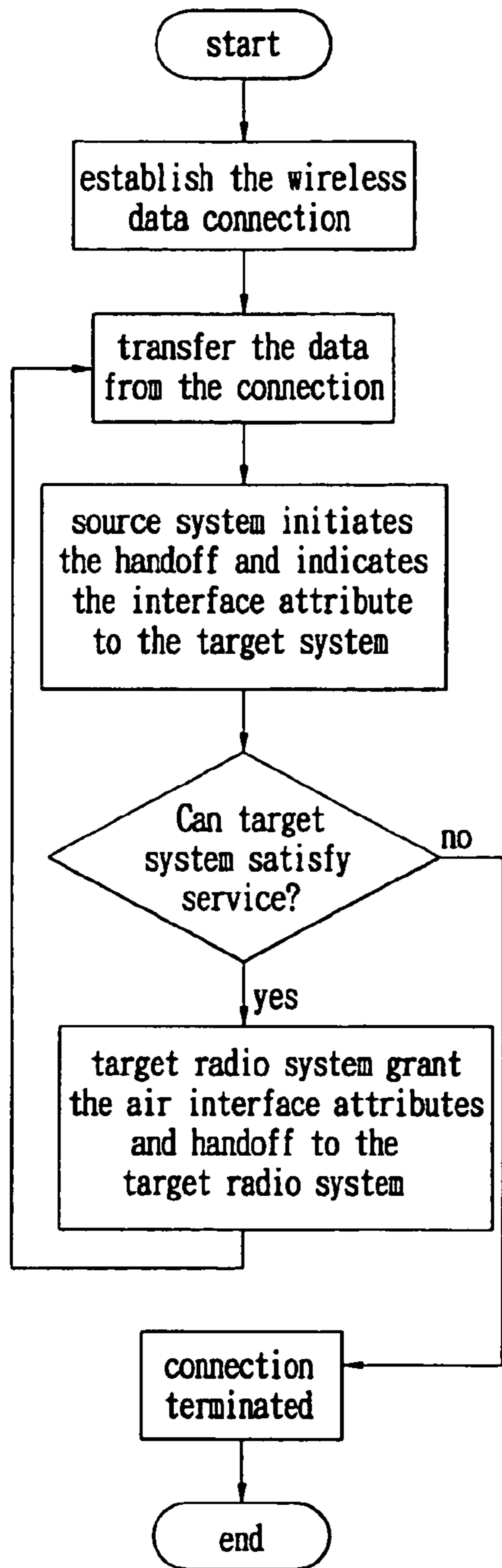


FIG. 1A
PRIOR ART

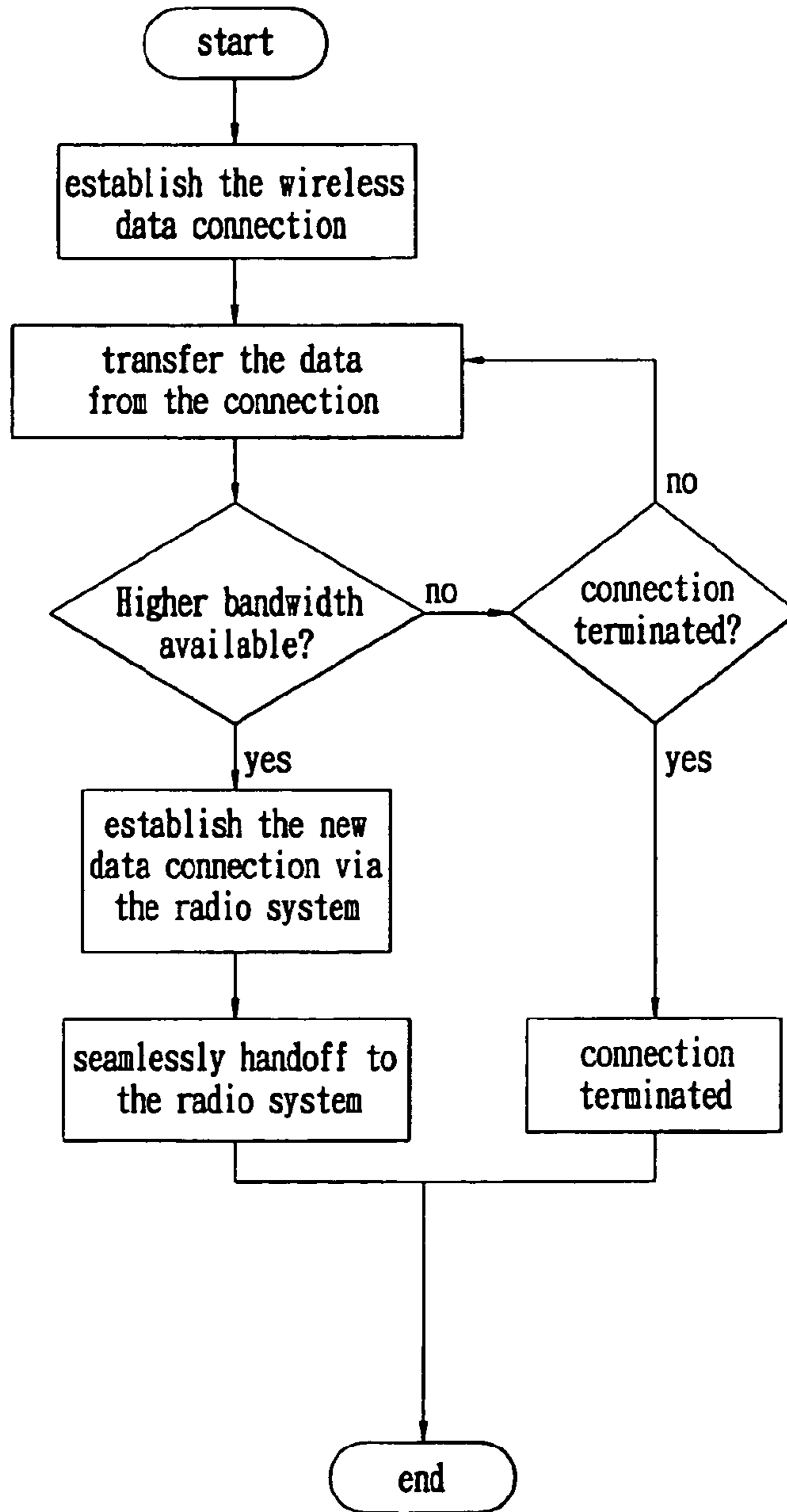


FIG. 1B
PRIOR ART

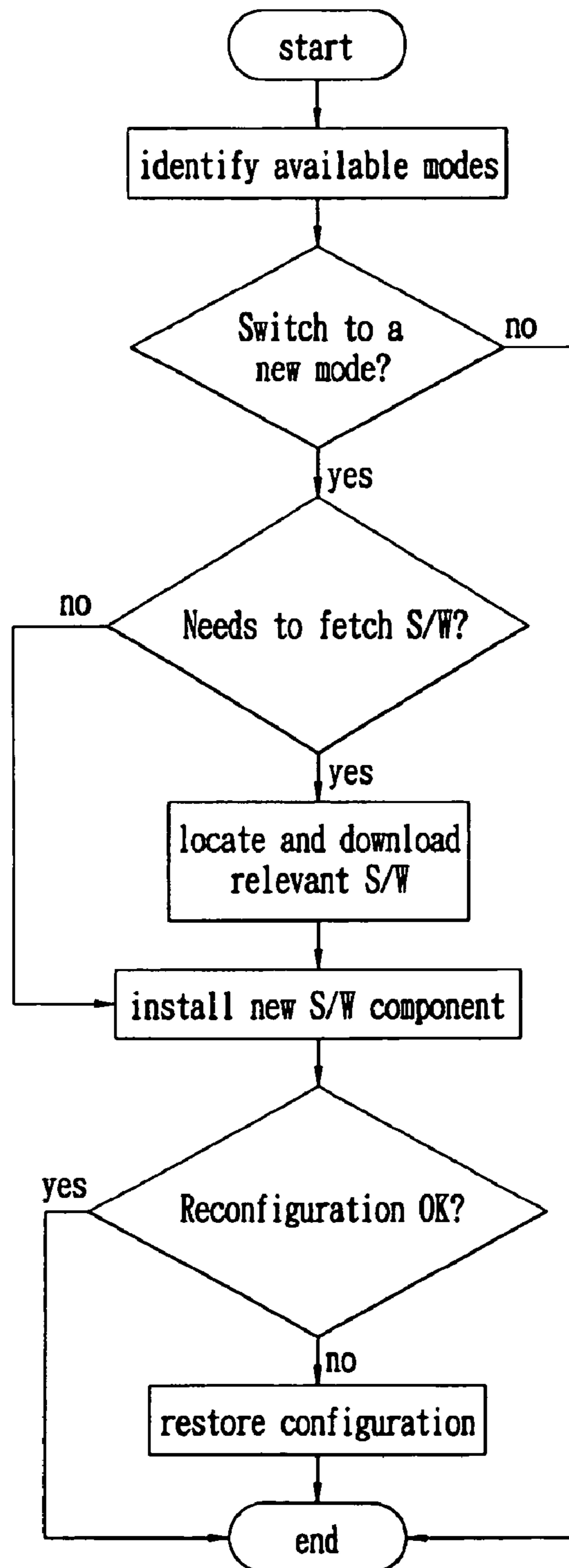


FIG. 2
PRIOR ART

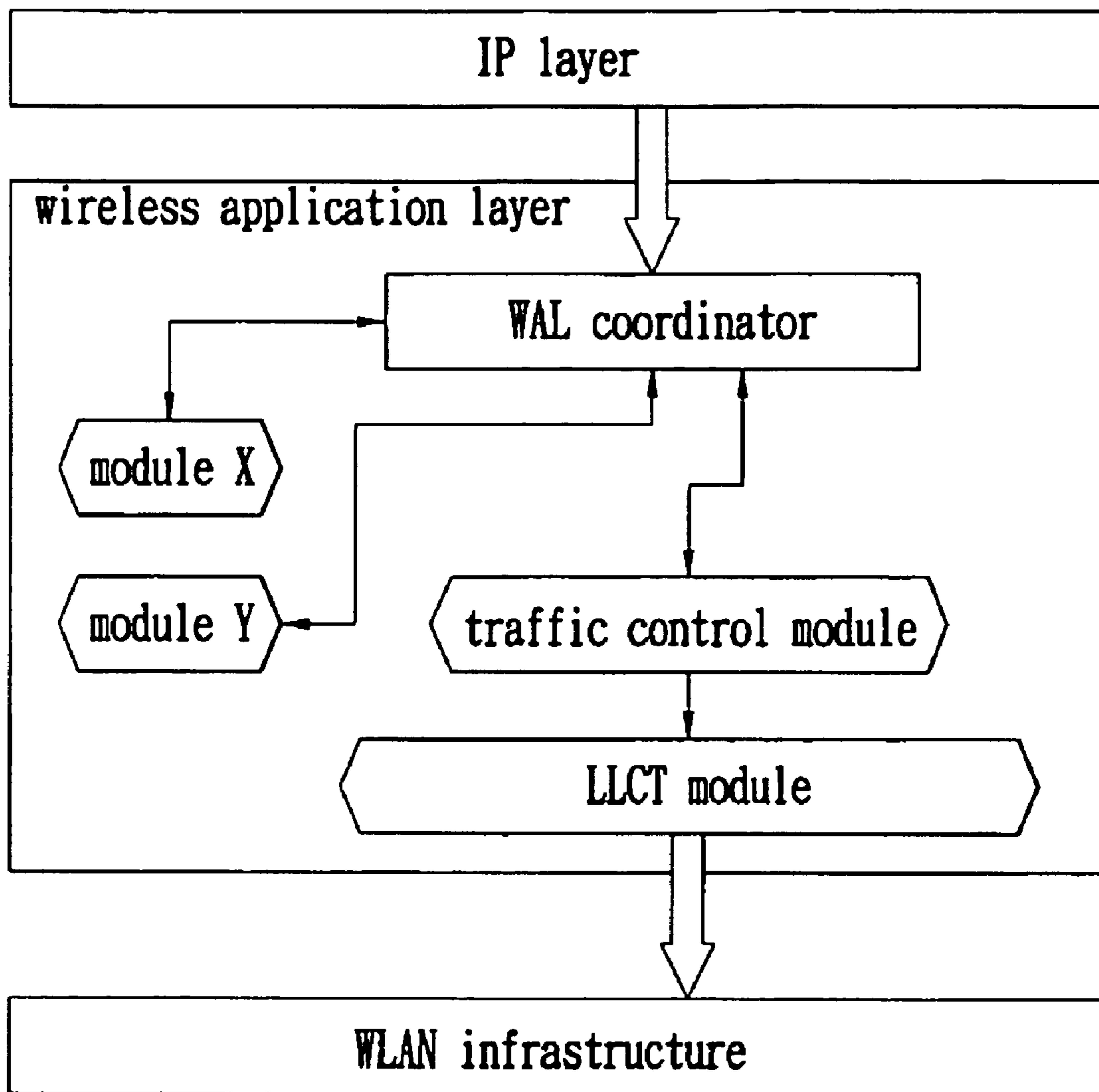


FIG. 3
PRIOR ART

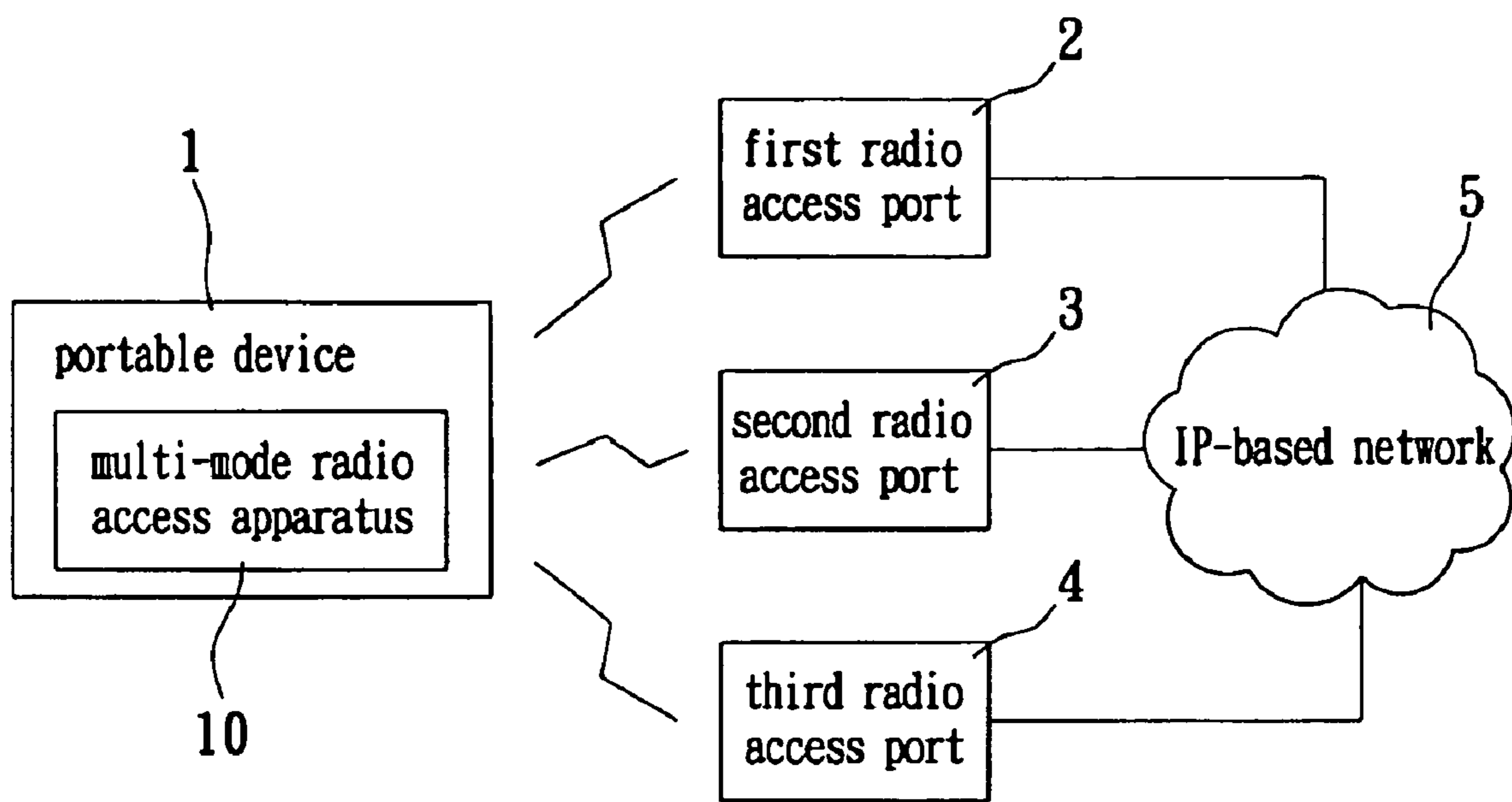


FIG. 4

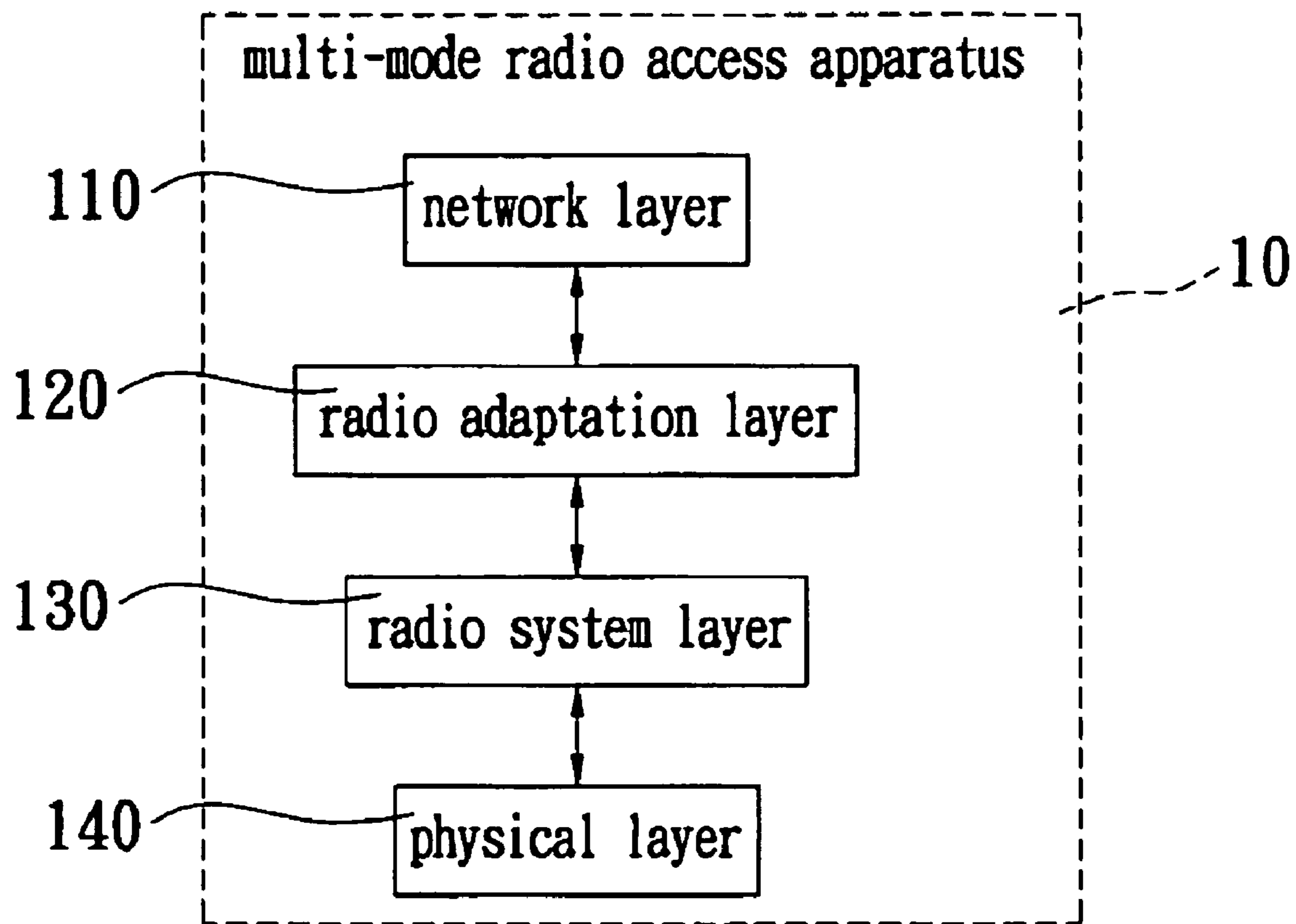


FIG. 5

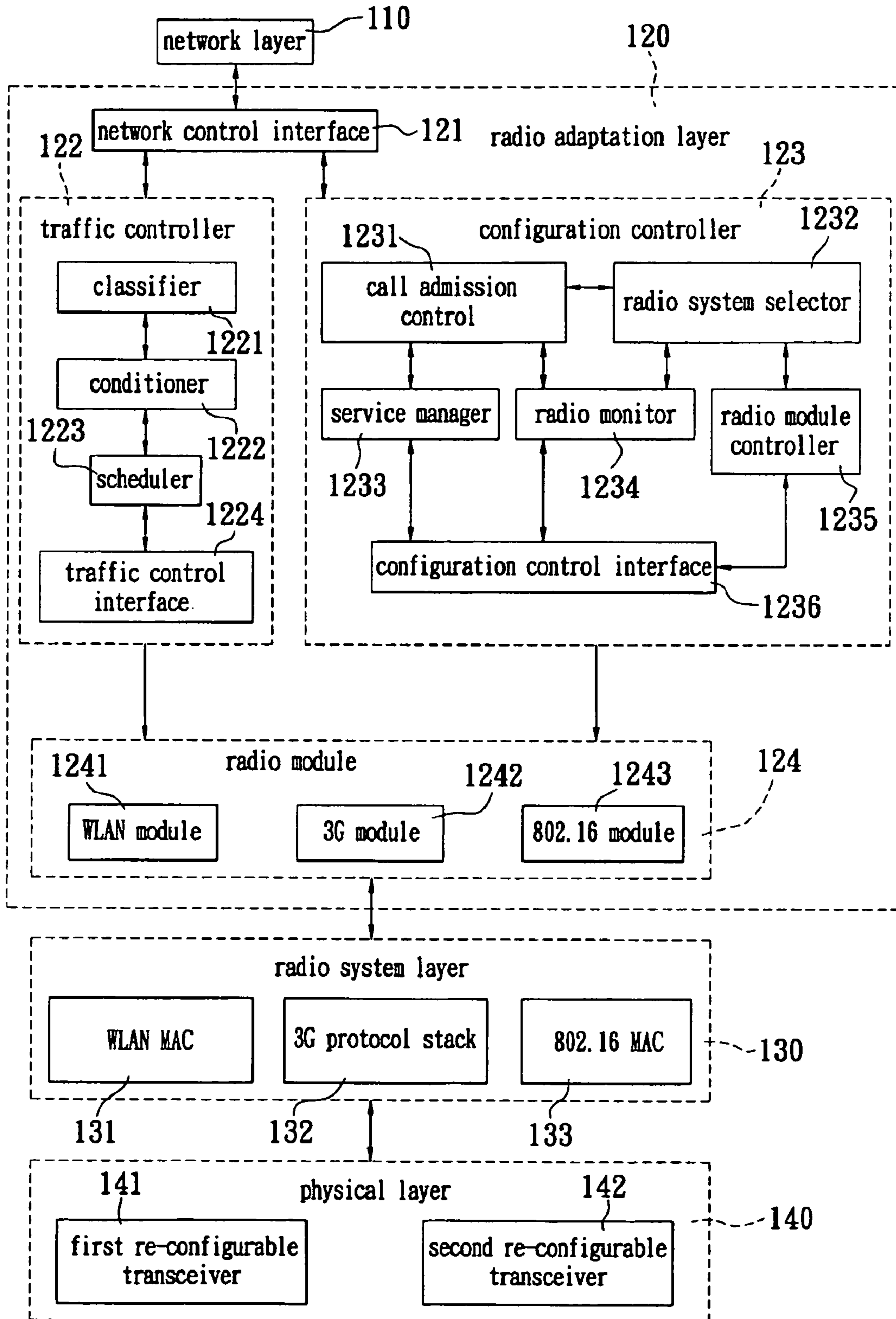


FIG. 6

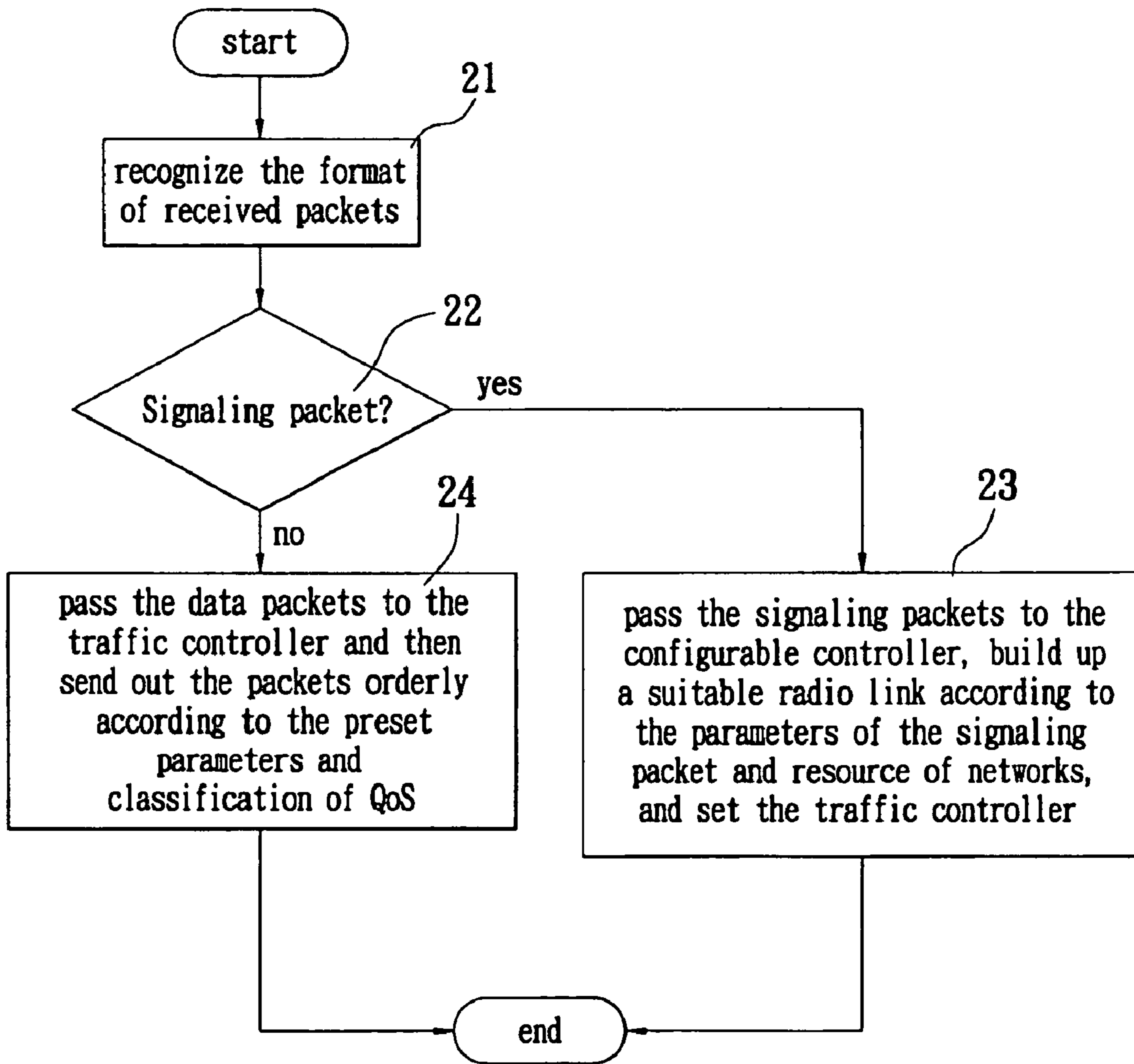


FIG. 7

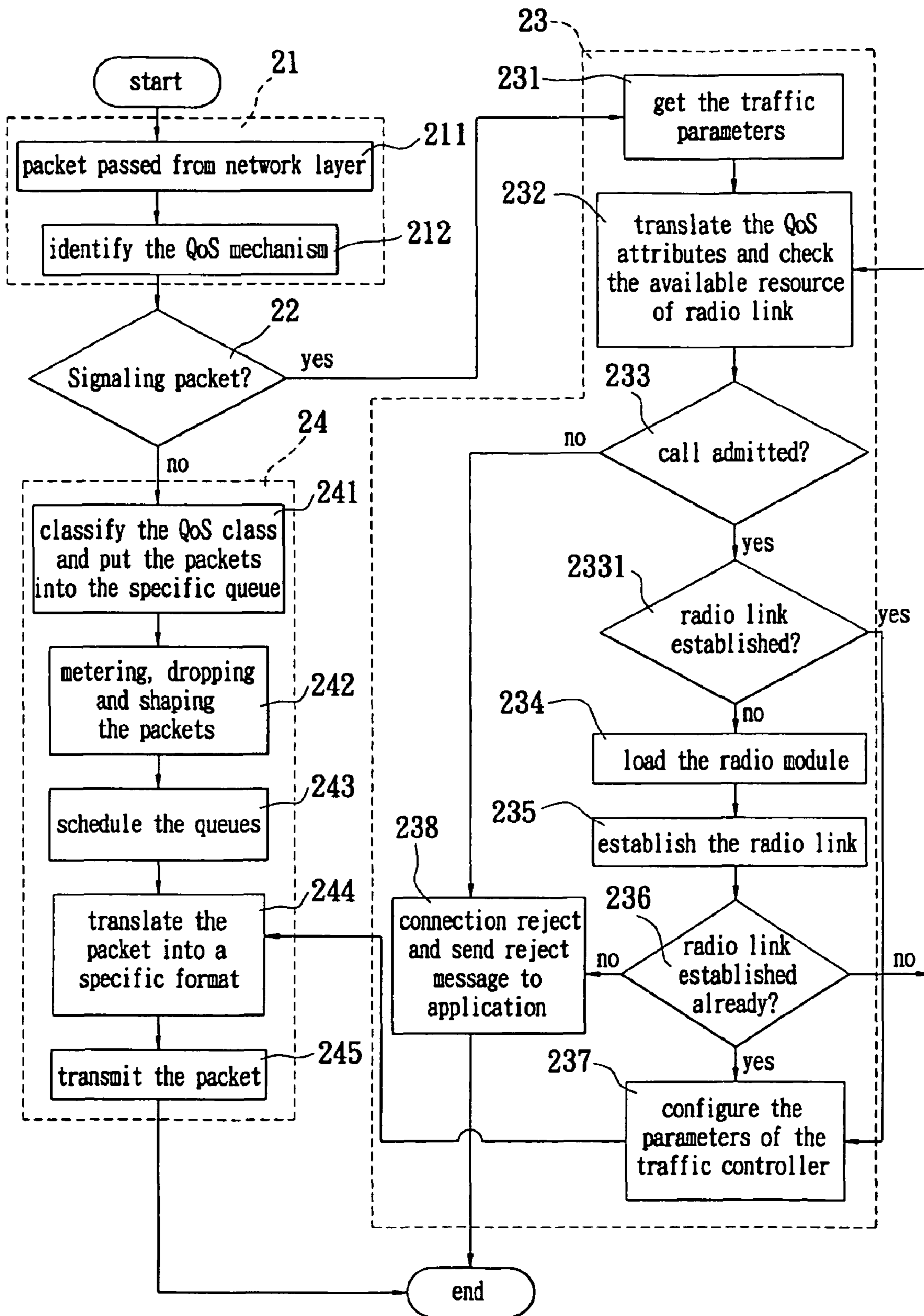


FIG. 8

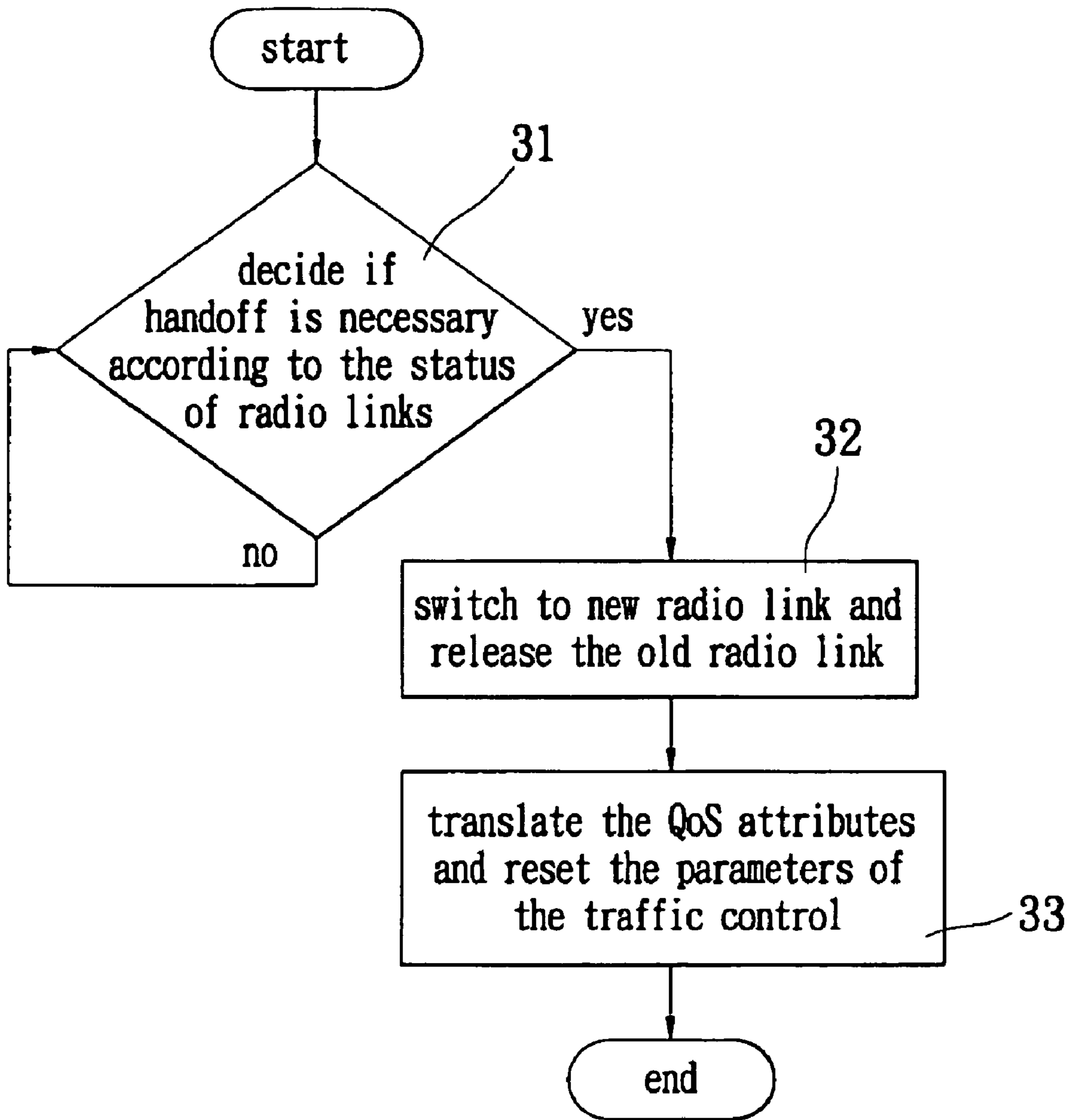


FIG. 9

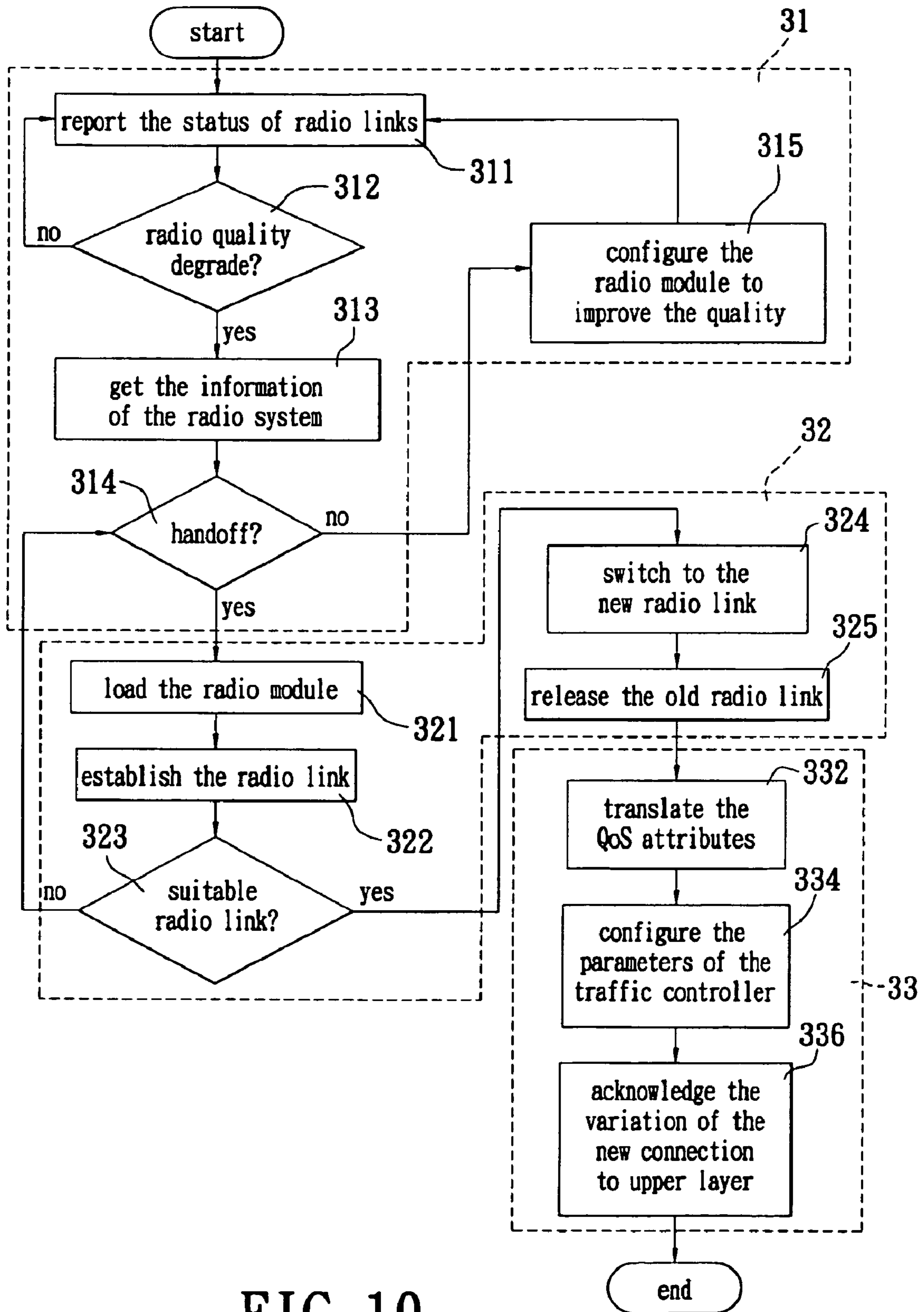


FIG. 10

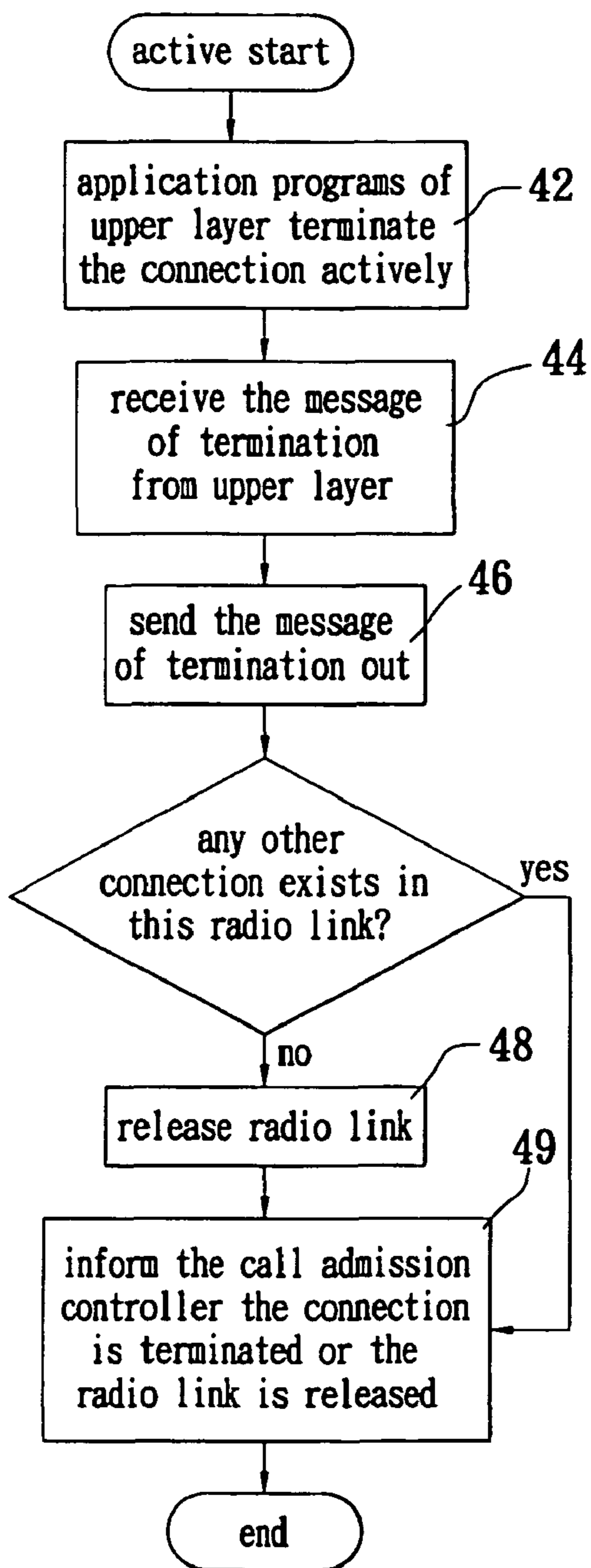


FIG. 11A

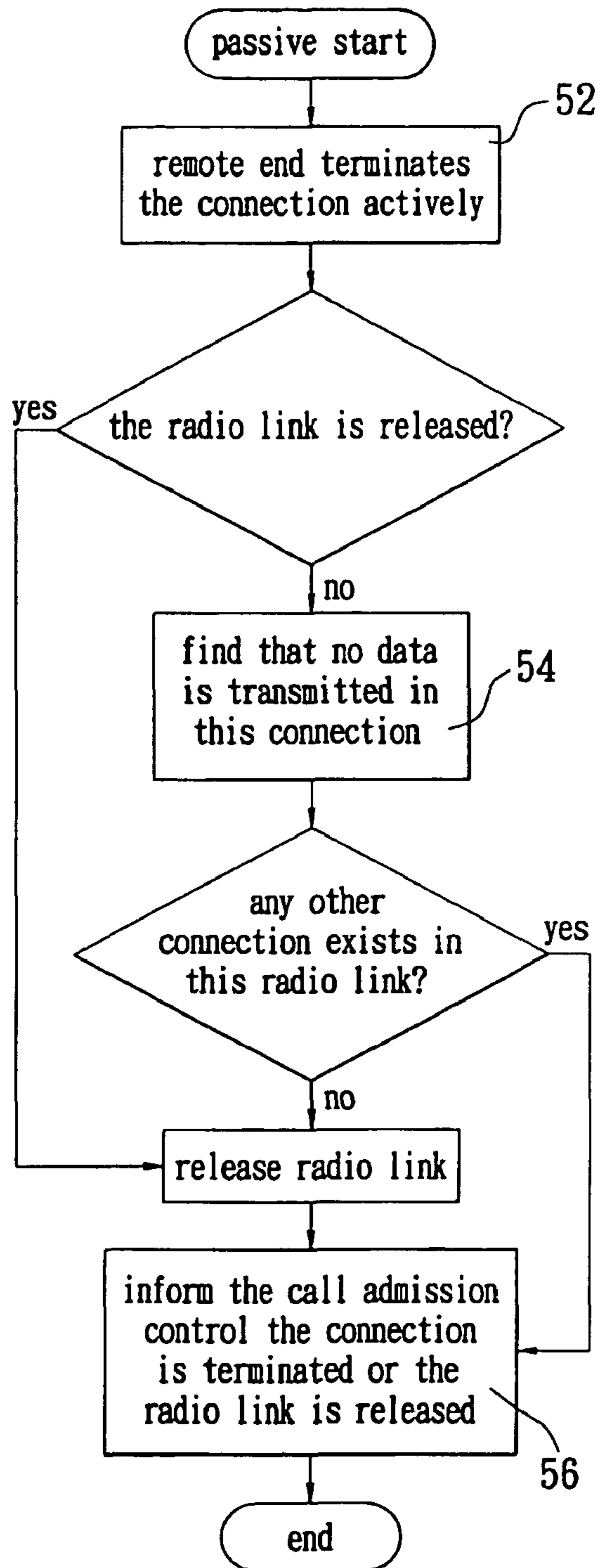


FIG. 11B

**APPARATUS FOR CONTROLLING
MULTI-MODE RADIO ACCESS AND
METHOD FOR THE SAME**

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

The present invention is directed to an apparatus for controlling multi-mode radio access and method thereof, and more particularly, to a system and a method that supports multi-mode reconfigurable media access control, quality of service (QoS) and seamless handoff in different radio systems so as to provide wire-line like QoS guarantee.

BACKGROUND OF THE INVENTION

As for conventional wireless communication apparatuses, in recent years, the Wireless Lan cards designed according to IEEE 802.11 protocol can be found at the market easily. The Wireless Lan card can be installed in a common personal computer (PC) or a portable computer. Via an access point (AP), the Wireless Lan card can communicate with a wired data network so that a user can use the Wireless Lan card to surf the network in a wireless manner.

In the recent development of the radio systems, the main issues include: QoS maintenance between different radio systems, management of radio modules, seamless handoff between radio system design for the beyond third generation (B3G) network.

In the field of QoS, some organizations are trying to define their own standards for radio systems, e.g. IEEE 802.11E protocol for wireless local area networks (WLAN), 3GPP TS23.107 for wideband code division multiple access (WCDMA) systems, etc. However, most of these standards are defined with individual QoS criteria adapted for their own wireless network structures. These standards only can guarantee a specific QoS at wireless terminals, but they can hardly support a QoS of wired networks. Hence, they can't satisfy the requirements of the end-to-end QoS.

In order to reach the end-to-end QoS guarantee, an interworking unit is usually used between different systems for communication and maintaining the QoS. However, different radio systems possess different network features and an additional interworking unit should be used for mapping the requirements of different QoS. Hence, this method is costly and easily induces the degradation of QoS during executing the mapping process.

As per seamless handoff, please refer to FIG. 1A, which is disclosed in "Enhanced handoff signaling for high speed data and multimedia," U.S. Pat. No. 6,205,128. This patent discloses a mechanism for handoff while the radio communication system finds the signal is too weak to maintain the connection quality. Once handoff is needed, the source system will first inform the wireless apparatus. Then, the wireless apparatus will execute the handoff process when the target system is ready. Please also refer to FIG. 1B, which is disclosed in "Method and system for seamless handoff between radio networks with a mobile terminal," U.S. Pat. No. 6,243,581. Some techniques can be used to search a more suitable radio link to make the wireless apparatus able to transfer data in the radio link with higher bandwidth after handoff.

As per multi-mode reconfigurable technology, please refer to FIG. 2, which illustrates an operation flowchart of a soft defined radio system mentioned in "Design and implementation of software framework for software defined radio system." VTC 2002-Fall, Volume: 4, 2002. By employing the mechanism of the this system, a wireless communication apparatus will first measure the magnitude of received signals and then decide if the software and hardware modules should be changed to adapt to a different system. However, the problems about seamless handoff are not considered in this system architecture. Hence, the transmission of this system will be interrupted during the module changing process.

Moreover, in "Reconfigurable terminals: an overview of architectural solution," IEEE Communications Magazine, to Vol. 39 Issue: 8, another system architecture designed in TRUST project of IST is introduced. This system architecture has mode monitoring, mode switching and software download mechanisms and reconfigurable baseband system structure. By employing this architecture, the mode monitoring mechanism will decide which radio system should be connected to when the wireless apparatus is actuated. Subsequently, the mode monitoring mechanism will decide if the wireless apparatus should be adjusted to connect with another system during its movement and then adjust the radio system via the mode switching and software download mechanisms. This reference paper also mentions the problem of service interruption occurred during mode switching due to there is only one wireless transceiver available in the hardware and recommends to employ two transceivers in the hardware to resolve this problem.

As per the radio system architecture beyond third generation, please refer to FIG. 3, a wireless application layer (WAL) is inserted between the network layer and the physical layer. The wireless application layer includes a WAL coordinator, a plurality of radio modules, a traffic control module and a logical link control translate module.

The WAL coordinator is used to recognize the networks the packets belong to and then invoke the radio modules to process the packets. Subsequently, the processed packets will be delivered to the traffic control module for scheduling. Finally, via the logical link control translate module, the packets will be passed to the physical layer for transmission. However, this system architecture is only suited to use in the radio systems with similar attributes, this system architecture can't be used to coordinate and communicate with the radio modules if the radio systems have completely different media access control mechanisms. Besides, this system architecture can't support seamless handoff due to this system architecture can only control a radio module at a time.

As mentioned above, in the prior art, QoS, multi-mode reconfigurable and seamless handoff mechanisms and system architecture beyond third generation have been proposed. However, the wire-line like QoS can't be reached by improving one or two of these techniques. For instance, real-time multimedia transmission can't be reached without QoS technique; the wireless apparatus can only transfer data in a single radio system without multi-mode reconfigurable technique and hence the wireless apparatus can't access the network anytime and anywhere; the QoS will be degraded and even interrupted during handoff process without seamless handoff technique.

Accordingly, as discussed above, the conventional wireless communication apparatuses still have some drawbacks that could be improved. The present invention aims to resolve the drawbacks in the prior art.

SUMMARY OF THE INVENTION

An objective of the present invention is to provide an apparatus and method for controlling multi-mode radio access,

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which supports multi-mode reconfigurable, QoS and seamless handoff in different radio systems so as to provide wire-line like QoS guarantee.

Another objective of the present invention is to provide an apparatus and method for controlling multi-mode radio access, which make a user able to use a single apparatus to access different radio systems via different radio access techniques.

For reaching the objectives above, the present invention provides an apparatus for controlling multi-mode radio access, which includes a network layer, a radio adaptation layer, a radio system layer and a physical layer. Therein, the radio adaptation layer is used to control the radio modules of the radio system layer to support the QoS needed in the upper layer. The radio adaptation layer is in charge of building up, correcting and seamless changing the radio link and used to make sure that data can be delivered to the lower layer orderly according to predetermined QoS requirements. The phrase “seamless” means low packet loss rate and low packet delay.

The present invention also provides a method for controlling multi-mode radio access, which includes a packet transmission process and a seamless handoff process. Therein, the packet transmission process includes: recognizing a format of a received packet; establishing a corresponding radio link according to parameters of the received signaling packet and present network resources, and setting corresponding parameters of a traffic controller; and performing scheduling according to the set parameters and the classes of QoS and then sending out the received data packet orderly.

Furthermore, the seamless handoff process includes: determining if handoff is necessary according to the status of the present radio link; switching to a new radio link and releasing an old radio link; establishing the radio link with suitable QoS; setting corresponding parameters of a traffic controller; and inform the upper layer the variation of the new radio link.

Numerous additional features, benefits and details of the present invention are described in the detailed description, which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1a is an operation flowchart of a handoff process according to the prior art.

FIG. 1b is an operation flowchart of another handoff process according to the prior art.

FIG. 2 is an operation flowchart of a soft defined radio system according to the prior art.

FIG. 3 is a schematic diagram of a radio system architecture beyond third generation according to the prior art.

FIG. 4 is a schematic diagram of a multi-mode radio access apparatus complied with the present invention.

FIG. 5 shows a schematic diagram of an internal structure of the multi-mode radio access apparatus complied with the present invention.

FIG. 6 shows a detailed block diagram of the internal structure of the multi-mode radio access apparatus complied with the present invention.

FIG. 7 is an operative flowchart of the packet-transmitting process complied with the present invention.

FIG. 8 is a detailed operative flowchart of the packet-transmitting process complied with the present invention.

FIG. 9 is an operative flowchart of the seamless handoff process complied with the present invention.

FIG. 10 is a detailed operative flowchart of the seamless handoff process complied with the present invention.

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FIGS. 11a and 11b are operative flowcharts of active and passive radio link releasing process complied with the present invention.

DETAILED DESCRIPTION

Please refer to FIG. 4, which is a schematic diagram of a multi-mode radio access apparatus complied with the present invention. The multi-mode radio access apparatus **10** of the present invention can be installed into a portable device **1**, e.g. notebook computer. The portable device **1** can use the multi-mode radio access apparatus **10** to connect with the first radio access port **2**, second radio access port **3** and third radio access port **4** to communicate with IP-based network (“IP” is the abbreviation of “Internet Protocol”). In practice, the number of radio access port is not limited and the first radio access port **2**, second radio access port **3** and third radio access port **4** can use different radio access techniques. We should emphasize that the order and number of the radio systems illustrated in FIG. 4 are not limited. The number of the radio systems can be one or multiple.

Please refer to FIGS. 5 and 6. FIG. 5 shows a schematic diagram of an internal structure of the multi-mode radio access apparatus **10** and FIG. 6 shows a detailed block diagram of the internal structure of the multi-mode radio access apparatus **10**. In FIG. 5, the multi-mode radio access apparatus **10** includes a network layer **110**, a radio adaptation layer **120**, a radio system layer **130** and a physical layer **140**.

The network layer **110** is used to support the application program of upper layer to provide the QoS mechanism of conventional Internet. Beside, the network layer **110** is also used to resolve the problems resulted from roaming within different wireless network systems. This layer has following functions.

The network layer **110** can use mobile IP to resolve the problems resulted from roaming within different wireless network systems. By employing mobile IP, the multi-mode radio access apparatus **10** can get a Care-of-Address (COA) during roaming and transfer data via the COA.

Regarding the portion of QoS, the network layer **110** can support IntServ, DiffServ or other QoS mechanisms. For instance, the network layer **110** can use RSVP protocol of IntServ to build up a preserved path in a network supporting IntServ or use DiffServ Core Point (DSCP) mechanism of DiffServ to mark packets so as to make the packets be transferred with predetermined QoS in a network supporting DiffServ.

As for the QoS mechanisms originally employed at the wired end in the network only, they can be supported in the radio adaptation layer **120** to make sure that the QoS in the network layer **110** can also be reached in different radio links. Hence, the QoS can be the same in the different layers of the multi-mode radio access apparatus **10**.

The radio adaptation layer **120** is mainly used to control the radio modules of the radio system layer **130** to provide radio links with the QoS needed in the upper layer. The radio adaptation layer **120** is in charge of building up, correcting and seamless changing the radio link and used to make sure that data can be delivered to the lower layer orderly according to predetermined QoS requirements when there are data ready to send in the upper layer.

The radio adaptation layer **120** also integrates with other QoS mechanisms originally used at the wired end in the network only. The radio adaptation layer **120** can coordinate the QoS of the upper layer and lower layer. On one hand, the radio adaptation layer **120** can cooperate with the IntServ and DiffServ mechanisms of user’s wireless devices; on the other

hand, the radio adaptation layer **120** also can cooperate with the IntServ and DiffServ mechanisms of the wired network.

As shown in FIG. 6, the radio adaptation layer **120** has a network control interface **121**, a traffic controller **122**, a configuration controller **123** and a radio module **124**. Therein, the network control interface **121** is a unified interface capable of cooperating with various application programs of upper layers. The network control interface **121** is in charge of analyzing packets from the network layer **110** and able to recognize the QoS requirements and classifications of the packets. After recognition process, the network control interface **121** will classify the packets and send the data and signaling packets to the traffic controller **122** and configuration controller **123**, respectively.

The configuration controller **123** is used to control and build up radio links and then set parameters of the traffic controller **122**. The configuration controller **123** has a call admission control **1231**, a radio system selector **1232**, a service manager **1233**, a radio monitor **1234**, a radio module controller **1235** and a configuration control interface **1236**.

The call admission control **1231** illustrated in FIG. 6 is in charge of managing the resource of wireless networks. The call admission control **1231** is used to determine if a radio link can be built up by employing the available radio resource according to the QoS requirements. The call admission control **1231** can also pre-build or rebuild a radio link according to different requirements and communicate with the radio system selector **1232** and radio monitor **1234** to obtain the last information about radio resource. After accepting the requirement of connection, the service manager **1233** set the parameters of the traffic controller **122** to make the traffic controller **122** deliver the data packets in accord with the QoS requirements.

The radio system selector **1232** of the configuration controller **123** is used to analyze the status of the wireless networks according to the radio link information from the radio monitor **1234**. The radio system selector **1232** will choose a most suitable radio link and perform seamless handoff for a user. At the same time, the radio system selector **1232** will also adjust itself dynamically in accordance with the radio link and make the call admission control **1231** and radio module controller **1235** to perform corresponding actions.

The service manager **1233** is able to perform commands from the call admission control **1231** to manage and control the components of the traffic controller **122**. The service manager **1233** is also used to control the radio module **124** to build up or change the radio links.

The radio monitor **1234** of the configuration controller **123** is in charge of monitoring the radio links. The radio monitor **1234** will make the radio module **124** to report back periodically or while being abnormal. Then, the radio monitor **1234** will provide the information of the present status of the radio link to the call admission control **1231** and the radio system selector **1232** for determining if a connection should be built up and if handoff is needed.

The radio module controller **1235** is used to load protocol software corresponding to accessed radio systems into the radio module **124**. The configuration control interface **1236** acts as a unified interface between the configuration controller **123** and radio module **124**.

The traffic controller **122** shown in FIG. 6 is used to control the traffic of the data packets to fulfill the QoS requirements. The traffic controller **122** has a classifier **1221**, a conditioner **1222**, a scheduler **1223** and a traffic control interface **1224**. Therein, the classifier **1221** will classify the data packets sent from the network control interface **121**. If the data packets are IntServ packets, the classifier **1221** will classify them in

accord with their radio links. After classified, the packets will be sent to the corresponding queues, respectively. Then, the conditioner **1222** will perform traffic control.

Moreover, the conditioner **1222** is used to manage the queues of the packets. The conditioner **1222** has a meter for measuring according to the data attributes and influencing parameters of other components, a dropper for dropping packets according the requirements of QoS, and a shaper for retarding the transmission of packets according the requirements of QoS (these components are not shown in FIG. 6). The schedulers **1223** is used to schedule the queues of different classifications according to the parameters set by the service manager **1233** and pass the packets to the radio module **124** for transmission. The traffic control interface **1224** acts as a unified interface between the traffic controller **122** and the radio module **124**.

The radio module **124** is used for transforming the format of the data packets before transmitting in different radio systems. The radio module **124** is also used to provide a radio link with suitable QoS for the traffic controller **122** and make the links of the application programs of the upper layer able to map to the radio links of the lower layer in a one-to-one or one-to-multiple manner. Further, the radio module **124** also provides some functions, such as monitoring or power saving, for the configuration controller **123** to change or set the radio module **124**. The radio module **124** includes a wireless local area network (WLAN) module **1241**, a 3G module **1242** and a 802.16 module **1243**. In practice, the radio module **124** can further include a bluetooth module or the modules employing other radio access techniques.

The radio system layer **130** has a WLAN media access controller (MAC) **131**, a 3G protocol stack **132** and a 802.16 MAC **133**. In practice, the radio system layer **130** can further include a bluetooth MAC or the MACs employing other radio access techniques. Via these media access controllers, the multi-mode radio access apparatus **10** can use various radio access ports, such as first radio access port **2**, second radio access port **3**, etc., to access the IP-based network **5**.

Furthermore, as an example only, the physical layer **140** shown in FIG. 6 has a first reconfigurable transceiver **141** and a second reconfigurable transceiver **142**. Both of the first reconfigurable transceiver **141** and second reconfigurable transceiver **142** can be re-configured to adapt to different radio systems. In practice, the physical layer **140** of the present invention can have a single reconfigurable transceiver only. Besides, the physical layer **140** can also have a non-reconfigurable transceiver.

During handoff, if the physical layer **140** has two or more transceivers, the physical layer **140** can use one transceiver to communicate with a radio system via a built radio link and use another one to connect with other radio systems simultaneously. Then, the physical layer **140** will be disconnected from the former radio system only after built up another radio link. By this way, the multi-mode radio access apparatus **10** can perform handoff seamlessly without any delay or disconnection from external networks.

In order to reach seamless handoff, requirements of QoS of Internet and functions of radio link, the multi-mode radio access method of the present invention includes a multi-mode reconfigurable control process, a packet-transmitting process (mainly for providing a QoS guaranteed radio link), a seamless handoff process and a radio link releasing process.

In the multi-mode reconfigurable control process, the configuration controller **123** uses the radio monitor **1234** to monitor the signals of radio links and the statuses of communication. Once problems induced in the radio links happen, the configuration controller **123** will change the setting of the

links or perform handoff. The configuration controller **123** can use the radio system selector **1232** to make a decision in accord with the requirements of QoS, and then use the service manager **1233** to change the setting of the radio module **124** or use the radio module controller **1235** to change the radio module **124** timely. Thereby, the configuration controller **123** can provide a user to change the setting of media access control dynamically and repeatedly.

As for providing a QoS guaranteed radio link, please refer to FIG. 7, which is an operative flowchart of the packet-transmitting process complied with the present invention. In the beginning, when the network control interface **121** receives packets from the network layer **110**, the network control interface **121** will recognize the format of the received packets so as to identify the QoS mechanism and distinguish the packets into signaling packets and data packets (steps **21** and **22**). The network control interface **121** will pass the signaling packets to the configuration controller **123** and pass the data packets to the traffic controller **122**.

When the configuration controller **123** receives a signaling packet, configuration controller **123** will use the call admission control **1231** to decide if building up a radio link is necessary according to the parameters of the signaling packet and the resource of the networks. Once deciding to build up a radio link, configuration controller **123** will use the service manager **1233** to control the radio system layer **130** to change the setting of the media access control for forming a suitable radio link or increase a new radio link. Then, configuration controller **123** will set the traffic controller **122** with corresponding parameters (step **23**).

On the other hand, when the traffic controller **122** receives a data packet, the traffic controller **122** will schedule the packet in accordance with the preset parameters and the classification of QoS and then send out the packet orderly to fulfill the requirements of QoS (step **24**).

Please refer to FIG. 8, which is a detailed operative flowchart of the packet-transmitting process complied with the present invention. Initially, the multi-mode radio access apparatus **10** is actuated, and then the network control interface **121** will start to receive signaling or data packets from the networks layer **110** (step **121**). When received packets from the network layer **110**, the network control interface **121** will recognize the format of the packets so as to identify the QoS mechanism and distinguish the packets into signaling packets and data packets (steps **212**). Then, the network control interface **121** will pass the signaling packets to the configuration controller **123** and pass the data packets to the traffic controller **122** (step **22**).

When received a signaling packet, the configuration controller **123** will get the traffic parameters from the packet (step **231**). Then, the call admission control **1231** will map or translate the QoS attributes and check the available resource of radio link (step **232**). Subsequently, the call admission control **1231** will decide if the call for connection establishment should be admitted according to the obtained information (step **233**).

After the call for connection establishment is admitted, the call admission control **1231** will load a corresponding radio module program into the radio module **124** if the corresponding radio link is not established (steps **2331** and **234**). Then, the call admission control **1231** will use the loaded radio module program to establish the corresponding radio link (step **235**). After that, the call admission control **1231** will check if the radio link is established already according to the status of connection (step **236**).

If the radio link is established completely, the call admission control **1231** will use the service manager **1233** to set the

traffic controller **122** with corresponding parameters so that the data packets can be delivered orderly according to the requirements of QoS (step **237**). On the contrary, if the connection establishment is failure or not admitted by the call admission control **1231**, the call admission control **1231** will send a rejecting message to the network layer **110** via the network control interface **121**.

On the other hand, after receiving a data packet, the classifier **1221** of the traffic controller **122** will classify the QoS class of the data packet and put the data packet into the specific queue (step **241**). Subsequently, the conditioner **1222** of the traffic controller **122** will perform metering, dropping and shaping the packet according to the attributes of the packet and the requirements of QoS (step **242**). Then, the scheduler **1223** of the traffic controller **122** will schedule the queues of different classes according the parameters set by the service manager **1233** and pass the packet to the radio module **124** (step **243**).

Afterward, the radio module **124** will execute the radio module program to translate the packet into a specific format suited to transmit in the corresponding radio system (step **244**). Then, the radio module **124** will pass the packet to a corresponding media access controller of the radio system layer **130** and transmit the packet via a corresponding transmitter of the physical layer **140** (step **245**).

Therefore, due to the setting of the traffic control of the radio adaptation layer **120** and the media access control of the radio system layer **130** can be changed repeatedly, the QoS between network layer **110** and the physical layer **140** can be integrated vertically. Besides, since the method or apparatus of the present invention can support the IntServ and DiffServ mechanisms or other QoS mechanisms, the method or apparatus of the present invention can extend the area of QoS to reach the wired ends of the network. If the core network also supports this QoS mechanism, the area of QoS can be further extended to another end of the link and the end-to-end QoS can be reached.

As for the seamless handoff process, please refer to FIG. 9, which is an operative flowchart of the seamless handoff process complied with the present invention. Therein, by employing the radio monitor **1234** to monitor the status of the radio links, the radio system selector **1232** can decide if handoff is necessary (step **31**).

If handoff is necessary, the system selector **1232** will search for a possible and suitable radio link via the radio module **124**. Once found, the system selector **1232** will use the service manager **1233** to build up this new radio link. Subsequently, the system selector **1232** will perform handoff, i.e. switch to the new radio link, and then release the old radio link (step **32**). As established completely, according to the properties of the new radio link, the QoS attributes will be translated and the parameters of the traffic controller **122** will be reset (step **33**). In this way, the present or future packets processed in the traffic controller **122** will be transmitted by this new radio link and the connection will not be interrupted and the QoS will not be reduced. Hence, the seamless handoff can be performed.

As for the detailed seamless handoff process, please refer to FIG. 10, which is a detailed operative flowchart of the seamless handoff process complied with the present invention. First, the radio monitor **1234** will monitor the status of radio links dynamically, including magnitude and interference of signals and so on, and then report the status to the radio system selector **1232** (step **311**). Subsequently, the radio system selector **1232** will determine if the radio quality degrades according to the status reported by the radio monitor **1234** (step **312**).

If the radio quality degrades, the radio system selector **1232** will abstract the information of the used radio system from the status reported by the radio monitor **1234** (step **313**). According to the information, the radio system selector **1232** can determine if handoff is necessary (step **314**). If not necessary, the radio system selector **1232** can improve the quality of the radio link by configuring the radio module **124** (step **315**).

However, if handoff is necessary, the radio system selector **1232** will control the radio module controller **1235** to load the radio module program to the radio module **124** (step **321**). After loaded, the service manager **1233** will use the radio module program to establish a new radio link (step **322**). As established, the radio monitor **1234** will report the status of the radio link to the radio system selector **1232**, which will determine if the radio link is suitable (step **323**).

As the suitable and usable radio link is found and established, the service manager **1233** will switch to the new radio link (step **324**) and release the old radio link (step **325**). Then, according to the properties of the new radio link, the QoS attributes will be translated (step **332**) and the parameters of the traffic controller **122** will be reset (step **334**). Thereby, the packets processed in the traffic controller **122** can be transmitted according to their requirements of QoS. Subsequently, the radio adaptation layer **120** will acknowledge the variation of the new connection to the upper layer, such as the network layer **110**, via the network control interface **121** (step **336**).

As described above, the seamless handoff process complied with the present invention releases the old radio link and transmits via a new radio link only after the suitable new radio link is established. Hence, the connection won't be interrupted and the QoS won't degrade due to handoff. Thereby, the seamless handoff can be performed.

As per the radio link releasing process, please refer to FIGS. **11a** and **11b**, which are operative flowcharts of active and passive radio link releasing process complied with the present invention. Please refer to FIG. **11a** again. When the application programs of the upper layer terminate a connection actively, the application programs will issue a message of termination (step **42**). Then, the network control interface **121** will receive this message (step **44**). After the traffic controller **122** sends out this message (step **46**), the network control interface **121** will determine if any other connections exist in this radio link. If no other connections exist in this radio link, the radio module will release this radio link (step **48**) and inform the call admission control **1231** that this radio link is released (step **49**). Otherwise, the radio link needn't be released and the radio module will just inform the call admission control **1231** that the connection is terminated.

On the contrary, as shown in FIG. **11b**, when the remote end terminates the connection actively (step **52**) and the radio link is released, the relative setting of the radio module will be modified to release the radio link and the call admission control **1231** will be informed that the radio link is released (step **56**). If the radio link is not released, the traffic controller **122** will find that no data is transmitted in this connection after a period of time (step **54**). Then, the traffic controller **122** will determine if any other connections exist in this radio link to transmit data there through. If positive, the radio link needn't be released and the radio module will just inform the call admission control **1231** that the connection is terminated (step **56**). Otherwise, the radio link will be released and the radio module will inform the call admission control **1231** that the radio link is released.

Summing up, the present invention proposes a novel apparatus and method for controlling multi-mode radio access, which can provide the integration and guarantee of the QoS,

such as IntServ and DiffServ mechanisms, seamless handoff during roaming in different wireless networks and multi-mode reconfigurable mechanism. Hence, the present invention can provide wire-line like QoS guarantee.

Although the present invention has been described with reference to the preferred embodiment thereof, the present invention will be understood that the invention is not limited to the details thereof. Various substitutions and modifications have been suggested in the foregoing description, and other will occur to those of ordinary skill in the art. Therefore, all such substitutions and modifications are embraced within the scope of the invention as defined in the appended claims.

What is claimed is:

1. An apparatus for controlling multi-mode radio access comprising:

a physical layer;

a radio system layer connecting with the physical layer for performing medium access control;

a radio adaptation layer, which connects with the radio system layer, at least comprising:

a configuration controller used to establish or control at least a radio link according to a signal packet so as to perform seamless handoff within different radio systems and set corresponding traffic control parameters; and

a traffic controller used to transmit a data packet according to the traffic control parameters and requirements of quality of service (QoS) of the data packet; and

a network layer for passing the data packet and signal packet to the radio adaptation layer, the network layer using an Internet protocol (IP) so as to make the apparatus able to roam within the different radio systems and support QoS mechanisms.

2. The apparatus as claimed in claim **1**, wherein the IP is a mobile IP.

3. The apparatus as claimed in claim **1**, wherein the QoS mechanisms comprise a IntServ or a DiffServ mechanism.

4. The apparatus as claimed in claim **1**, wherein the physical layer comprises a first reconfigurable transceiver and a second reconfigurable transceiver for establishing radio links within the different radio systems.

5. The apparatus as claimed in claim **1**, wherein the physical layer only has a first reconfigurable transceiver or a non-reconfigurable transceiver.

6. The apparatus as claimed in claim **1**, wherein the radio system layer comprises at least a media access controller corresponding to a radio module.

7. The apparatus as claimed in claim **6**, wherein the media access controller is a wireless local area network (WLAN) media access controller, a 3G protocol stack, a 802.16 media access controller or a bluetooth media access controller.

8. The apparatus as claimed in claim **1**, wherein the radio adaptation layer further comprises a network control interface to recognize a format of a packet sent from the network layer.

9. The apparatus as claimed in claim **1**, wherein the configuration controller comprises:

a call admission control for managing present wireless network resources of the apparatus; and

a radio system selector connecting with the call admission control for determining if it is necessary to perform the seamless handoff according to a status of a radio link.

10. The apparatus as claimed in claim **9**, wherein the configuration controller comprises:

a service manager connecting with the call admission control for setting the traffic control parameters, and establishing or correcting the status of the radio link;

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a radio monitor connecting with the call admission control and the radio system selector for monitoring the status of the radio link; and

a radio module controller connecting with the radio system selector for loading a radio module program to a radio module.

11. The apparatus as claimed in claim 10, wherein the configuration controller comprises:

a configuration control interface connecting with the service manager, the radio monitor and the radio module controller for providing an unified control interface between the configuration controller and the radio module.

12. The apparatus as claimed in claim 1, wherein the traffic controller comprises:

a classifier for classify the data packet and deliver the classified data packet to a corresponding queue;

a conditioner connecting with the classifier for controlling the classified data packet in the queue;

a scheduler connecting with the conditioner for scheduling the queue according to the traffic control parameters; and

a traffic control interface connecting with the scheduler for providing an unified control interface between the traffic controller and a radio module.

13. The apparatus as claimed in claim 12, wherein the conditioner comprises:

a meter for measuring and counting according to data attributes of the data packet;

a dropper for dropping the data packet according the requirements of QoS; and

a shaper for retarding a transmission of the data packet according the requirements of QoS.

14. The apparatus as claimed in claim 1, wherein the radio adaptation layer further comprises:

a radio module connecting with the configuration controller and the traffic controller for converting the data packet to a specific radio system format before sending the data packet to the radio link, providing the radio link with QoS in an one-to-one or one-to-multiple manner and performing a monitoring of management and power saving to make the configuration controller able to modify the radio module.

15. The apparatus as claimed in claim 14, wherein the radio module comprises at least a radio module corresponding to the radio systems.

16. The apparatus as claimed in claim 15, wherein the radio module is a WLAN module, a 3G module, a [802.15] 802.16 module or a bluetooth module.

17. A packet-transmitting method for controlling multi-mode radio access comprising:

recognizing a format of a received packet;

determining if the received packet is a signaling packet;

passing the received packet to a configuration controller if the received packet is the signaling packet,

establishing a corresponding radio link according to parameters of the signaling packet and present network resources, and setting corresponding parameters of a traffic controller to fit predetermined requirements of QoS; and

passing the received packet to the traffic controller if the received packet isn't the signaling packet but a data packet, controlling a quality of a connection according to predetermined parameters of traffic control and then sending out the data packet orderly.

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18. The method as claimed in claim 17, wherein the step of passing the received packet to the configuration controller further comprises:

abstracting a traffic parameter from the signal packet;

translating QoS attributes and checking available resource of radio link;

loading a usable radio module program to establish the corresponding radio link if a connection is admitted;

setting the corresponding parameters of the traffic controller after the radio link is established completely; and

converting the signaling packet to a specific radio system format and then sending the signaling packet out.

19. The method as claimed in claim 18, wherein the step of passing the received packet to the configuration controller further comprises:

rejecting connection establishment and sending out a message of rejection if the connection is not admitted or the radio link isn't able to establish completely.

20. The method as claimed in claim 17, wherein the step of passing the received packet to the traffic controller further comprises:

classifying the data packet and delivering the classified data packet to a corresponding queue;

measuring, dropping or retarding the data packet;

scheduling a plurality of queues; and

converting the data packet to a specific radio system format for transmitting in a corresponding radio system; and sending the data packet out.

21. A seamless handoff method for controlling multi-mode radio access comprising:

determining if handoff is necessary according to a status of a present radio link, further comprising:

reporting the status of the present radio link;

determining if a quality of the present radio link degrades;

obtaining an information of a radios system and determining if the handoff is necessary; and

modifying a setting of a radio module to improve the quality of the present radio link if the handoff isn't necessary;

switching to a new radio link;

releasing an old radio link;

translating QoS attributes for mapping parameters; and

setting parameters of a traffic controller to fit the new radio link.

22. The method as claimed in claim 21 comprising following steps before the step of switching:

loading a radio module program and setting its parameters; establishing the new radio link by employing the radio module program; and

determining if the new radio link is suitable.

23. The method as claimed in claim 21 comprising a step as below after the step of setting:

informing an upper layer of a variation of the new radio link.

24. A radio link releasing method for controlling multi-mode radio access comprising:

issuing a message for releasing a radio link as an application program of an upper layer terminates a connection actively;

passing the message for releasing the radio link to an end of a network;

releasing the radio link by a radio module if a number of other connections existing in the radio link is zero and informing a call admission control that the radio link is released; and

informing the call admission control that the connection is terminated if the number of other connections existing in the radio link is not zero.

25. The method as claimed in claim 24 comprising a step as following when the application program of the upper terminates the connection passively: informing the call admission control that the radio link is released if the radio module issues that the radio is released.

26. The method as claimed in claim 25 comprising following steps if the radio module doesn't issue that the radio is released:

discovering that the radio is released by the radio module after a period of time;

releasing the radio link by the radio module if a number of other connections existing in the radio link is zero and informing the call admission control that the radio link is released; and

informing the call admission control that the connection is terminated if the number of other connections existing in the radio link is not zero.

27. *An apparatus for controlling multi-mode radio access, comprising:*

at least one transceiver;

a plurality of media access controllers coupled to the at least one transceiver, the plurality of media access controllers being configured to provide a plurality of radio access ports;

a first control unit coupled to one of the plurality of medium access controllers to establish at least one radio link so as to perform a substantially seamless handoff among different radio systems and to set control parameters; and

a second control unit configured to transmit, via one of the plurality of medium access controllers, a data packet according to the control parameters and requirements of quality of service (QoS) of the data packet; and

a network control interface coupled to the first and second control units to provide data to the first and second control units, the network control interface being configured to support an Internet protocol (IP) so as to enable handoff among the different radio systems and to support QoS mechanisms.

28. *The apparatus as claimed in claim 27, further comprising:*

at least one radio module coupled between the first and second control units and the plurality of media access controllers to enable access between the first and second control units and the plurality of media access controllers.

29. *The apparatus as claimed in claim 28, wherein the network control interface provides a packet containing signaling data to the first control unit to set the control parameters.*

30. *The apparatus as claimed in claim 29, wherein the first control unit comprises a call admission control unit for managing wireless network resources of the apparatus.*

31. *The apparatus as claimed in claim 30, wherein the first control unit further comprises:*

a service manager coupled to the call admission control unit to set the control parameters, and to set status of the at least one radio link; and

a radio monitor to monitor the status of the at least one radio link.

32. *The apparatus as claimed in claim 31, wherein the first control unit further comprises a configuration control inter-*

face coupled to the service manager and the radio monitor to provide a control interface between the first control unit and the at least one radio module.

33. *The apparatus as claimed in claim 31, wherein the first control unit further comprises a radio system selector coupled to the call admission control to determine whether to perform the substantially seamless handoff according to status of one of the at least one radio link.*

34. *The apparatus as claimed in claim 27, wherein the network control interface provides the data packet to the second control unit to transmit the data packet.*

35. *The apparatus as claimed in claim 34, wherein the second control unit comprises:*

a classifier for classifying the data packet and delivering the classified data packet to a queue;

a conditioner coupled to the classifier to control the classified data packet in the queue;

a scheduler coupled to the conditioner to schedule the queue according to the control parameters; and

a traffic control interface coupled to the scheduler to provide a unified control interface between the second control unit and the at least one radio module.

36. *The apparatus as claimed in claim 35, wherein the conditioner comprises:*

a meter for measuring and counting according to data attributes of the data packet;

a dropper for dropping the data packet according to the requirements of QoS; and

a shaper for retarding a transmission of the data packet according the requirements of QoS.

37. *The apparatus as claimed in claim 27, wherein the IP is mobile IP.*

38. *The apparatus as claimed in claim 27, wherein the QoS mechanisms include at least one of an IntServ mechanism and a DiffServ mechanism.*

39. *The apparatus as claimed in claim 27, wherein the plurality of media access controllers include at least one of a wireless local area network (WLAN) media access controller, a wideband code division multiple access (WCDMA) controller, a 802.16 media access controller, and a bluetooth media access controller.*

40. *The apparatus as claimed in claim 28, where the at least one radio module is coupled to the first and second control units to convert the data packet to a specific radio system format before sending the data packet to the at least one radio link, and to provide the at least one radio link with QoS in a one-to-one or one-to-multiple manner.*

41. *The apparatus as claimed in claim 40, wherein the at least one radio module includes at least one of a WLAN module, a 3G module, a 802.16 module, and a bluetooth module.*

42. *The apparatus as claimed in claim 27, wherein the network control interface is configured to recognize a packet sent from a network layer.*

43. *The apparatus as claimed in claim 27, wherein the first control unit comprises a radio module controller for establishing at least one radio link of at least one radio module.*

44. *A packet-transmitting method for controlling multi-mode radio access comprising:*

receiving a plurality of packets from a control interface;

setting control parameters of the multi-mode radio access in response to one of the plurality of packets for establishing at least one radio link so as to perform a substantially seamless handoff among different radio systems;

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processing a data packet from the plurality of packets according to the control parameters and requirements of quality of service (QoS) of the data packet
controlling a quality of a connection according to the requirements of QoS;
transmitting the data packet; and
providing handoff among the different radio systems with QoS mechanisms based on an Internet protocol (IP).
 45. *The method as claimed in claim 44, wherein the establishing further comprises:*
translating QoS attributes and checking available resources of radio link; and
establishing the radio link via at least one radio module based on the translated QoS attributes.
 46. *The method as claimed in claim 44, wherein the controlling the quality further comprises:*
measuring, dropping or retarding the data packet; and
converting the data packet to a specific radio system format for transmitting in a radio system.
 47. *A packet-transmitting method for controlling multi-mode radio access comprising:*
providing a plurality of media access controllers coupled to at least one transceiver to provide a plurality of radio access ports;

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selecting a radio module to connect to one of the plurality of medium access controllers to establish at least one radio link via the at least one transceiver;
transmitting, via one of the plurality of medium access controllers, a packet according to requirements of quality of service (QoS) of the packet;
monitoring status of the at least one radio link;
determining a condition for a substantially seamless handoff among different radio systems based on the status of the at least one radio link;
connecting a different one of the plurality of medium access controllers so as to enable handoff among the different radio systems and support QoS mechanisms based on an Internet protocol (IP).
 48. *The method as claimed in claim 47, wherein the radio module is configured to:*
convert packets to a specific radio system format before sending the packets to the at least one radio link; and
provide the at least one radio link with QoS in a one-to-one or one-to-multiple manner.
 49. *The method as claimed in claim 47, wherein the radio module include a WLAN module, a 3G module, a 802.16 module, or a bluetooth module.*

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