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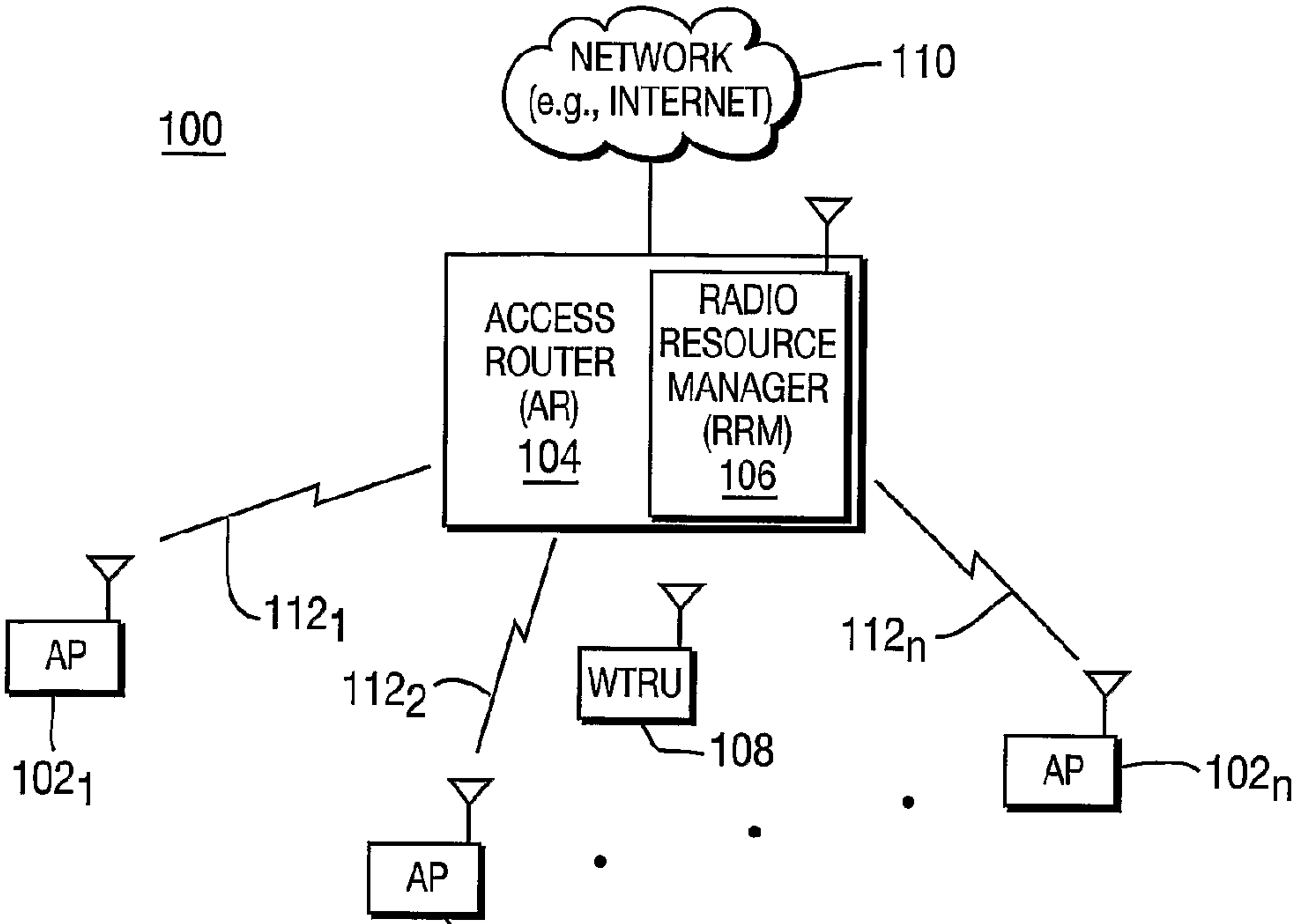
(54) Title: METHOD AND APPARATUS FOR MANAGING WIRELESS COMMUNICATION NETWORK RADIO RESOURCES



(57) Abrégé/Abstract:
A method and apparatus for managing radio resources in one or more wireless communication networks. At least one radio resource manager (RRM) (106) is provided within a network node, or as an independent entity. The RRM (106) monitors performance on wireless communication links of the network(s) and interacts with nodes (102-1-102-n) associated with those links to change the configuration on a particular wireless communication link if its performance (i.e., quality) falls below an established threshold. Information regarding current resource usage of the network is sent to the RRM (106) by the nodes (102-1-102n). Each of the nodes (102-1102-n) may send a quality report to the RRM (106) including wireless communication link quality measurements and performance statistics.

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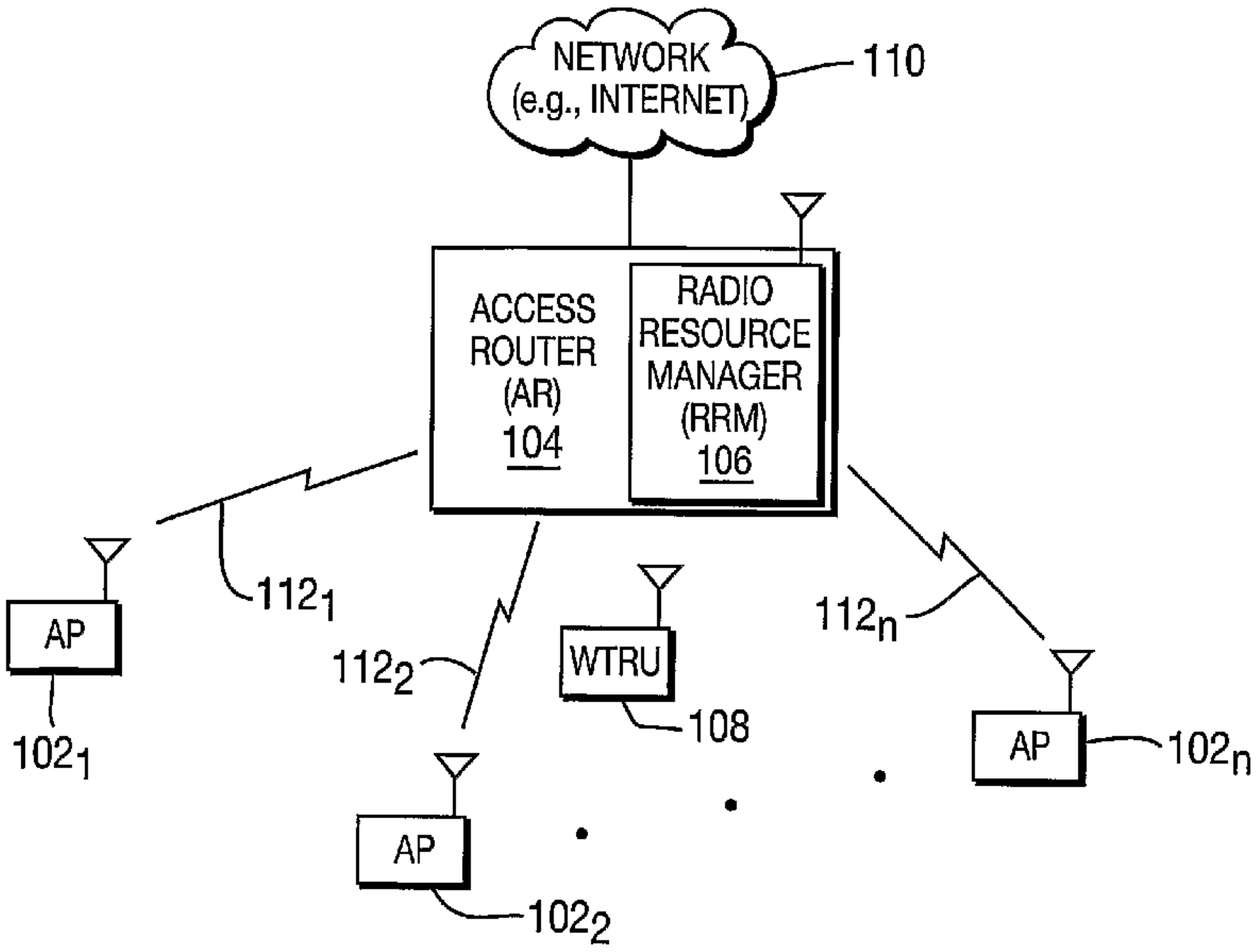
(54) **Title:** METHOD AND APPARATUS FOR MANAGING WIRELESS COMMUNICATION NETWORK RADIO RESOURCES



(57) **Abstract:** A method and apparatus for managing radio resources in one or more wireless communication networks. At least one radio resource manager (RRM) (106) is provided within a network node, or as an independent entity. The RRM (106) monitors performance on wireless communication links of the network(s) and interacts with nodes (102-1-102-n) associated with those links to change the configuration on a particular wireless communication link if its performance (i.e., quality) falls below an established threshold. Information regarding current resource usage of the network is sent to the RRM (106) by the nodes (102-1-102n). Each of the nodes (102-1102-n) may send a quality report to the RRM (106) including wireless communication link quality measurements and performance statistics.

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[0001] METHOD AND APPARATUS FOR MANAGING WIRELESS COMMUNICATION NETWORK RADIO RESOURCES

[0002] FIELD OF INVENTION

[0003] The present invention relates to wireless communication networks. More particularly, the present invention relates to a method and apparatus for managing radio resources in one or more wireless communication networks.

[0004] BACKGROUND

[0005] A wireless access network comprises a plurality of nodes, such as access points (APs), (i.e., base stations), access routers and wireless transmit/receive unit (WTRU). The nodes are connected to each other to establish a backhaul network. Traffic which originates from or is destined to the network is routed through the backhaul network.

[0006] The backhaul network may be established with wireless communication links. Establishing a backhaul network with wireless communication links has advantages over a wired backhaul network, such as ease of deployment, low cost and flexibility to implement future changes.

[0007] In a wireless backhaul network, interference from other co-deployed networks not only affects the radio links between the nodes and WTRUs operating in the affected region, but also the links between the network nodes.

[0008] A mesh network is a network comprising a plurality of nodes, each of which is connected to at least one neighboring node such that traffic may be routed via one or more hops through the network. In the mesh network, a degradation of the link throughput between two nodes is carefully observed for routing purposes, since the throughput on a critical link could affect the overall performance of the network. The degradation can be caused by several factors, such as an increase in interference. As the degradation exceeds a certain level, an alternative routing path is allocated through the mesh network. The time-varying and dynamic nature of the mesh network topology makes it necessary to take interference into account beyond initial deployment.

[0009] For example, if a wireless backhaul network is deployed next to an existing wireless network, additional interference generated by the subsequent network can bring down some of the links in the existing network. This is a potential problem, especially in public bands such as the 2.4 GHz industrial, scientific and medical (ISM) band with scarce frequency channels.

[0010] When two mesh networks are operating simultaneously in the same proximity, one or more of the nodes of a first mesh network may roam close to a second mesh network. This may cause interruption or severe interference to the second mesh network. This is especially problematic with radio equipment having relaxed adjacent channel protection and receiver sensitivity requirements. Therefore, there is a need for dynamic radio resource management and access coordination for the radio access network.

[0011] SUMMARY

[0012] The present invention relates to a method and apparatus for managing radio resources in one or more wireless communication networks. At least one radio resource manager (RRM) is provided within a network node, or as an independent entity. The RRM monitors performance on wireless communication links of the network(s) and interacts with nodes associated with those links to change the configuration on a particular wireless communication link if its performance (i.e., quality) falls below an established threshold. Information regarding current resource usage of the network is sent to the RRM by the nodes. Each of the nodes may send a quality report to the RRM including wireless communication link quality measurements and performance statistics. Alternatively, the RRM may perform the wireless communication link quality measurements. The RRM facilitates the broadcasting of information regarding current resource usage of one network to other networks to avoid collisions and interference.

[0013] BRIEF DESCRIPTION OF THE DRAWINGS

[0014] A more detailed understanding of the invention may be had from the following description of a preferred embodiment, given by way of example and to be understood in conjunction with the accompanying drawing wherein:

[0015] Figure 1 shows an exemplary point-to-multipoint (PtMP) backhaul network including an RRM in accordance with one embodiment of the present invention; and

[0016] Figure 2 shows a wireless communication system including a plurality of networks including a mesh network and an RRM operating in accordance with another embodiment of the present invention.

[0017] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] Hereafter, the terminology "WTRU" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, or any other type of device capable of operating in a wireless environment. When referred to hereafter, the terminology "node" includes but is not limited to a Node-B, a base station, an AP, a mesh point (MP), a site controller or any other type of interfacing device in a wireless environment.

[0019] The present invention is applicable to any type of wireless communication systems including, but not limited to, IEEE 802.11, IEEE 802.15 and IEEE 802.16 networks.

[0020] In accordance with the present invention, a backhaul network is established with wireless communication links. The backhaul network may be deployed with point-to-point (PtP), PtMP or mesh topologies. Mixed-mode access networks, (e.g., IEEE 802.16 backhaul network to serve IEEE 802.11 APs), and redundant and re-configurable network functionalities are also supported.

[0021] Figure 1 shows an exemplary PtMP backhaul network 100 operating in accordance with one embodiment of the present invention. The backhaul network 100 includes a plurality of APs 102_1-102_n, an RRM 106 and at least one WTRU 108. The RRM 106 may reside in any node in the network 100, or be configured as a separate, independent entity. In Figure 1, the RRM 106 is shown as being located in an access router (AR) 104 which provides access to an access network 110, such as the Internet. The RRM 106 monitors the quality of wireless backhaul links 112_1 - 112_n between respective ones of the APs 102_1-102_n and the AR 104. The APs 102_1-102_n may generate channel quality reports associated with wireless backhaul links 112_1 - 112_n which are received by the RRM 106, and/or the RRM 106 may perform quality measurements on the wireless backhaul links 112_1 - 112_n. The quality reports include measurements and performance statistics. The performance may be evaluated with any metrics including, but not limited to, throughput, signal power, a block error rate, a bit error rate, a signal-to-interference ratio (SIR) or the like. The RRM 106 monitors performance on the wireless communication links 112_1 - 112_n in the backhaul network 100.

[0022] If the RRM 106 observes performance of a particular wireless backhaul link 112_1 - 112_n drops below a threshold, the RRM 106 dynamically interacts with other nodes in the backhaul network 100 to recover the performance. For example, the RRM 106 may change the operating frequency of the wireless communication link 112_1. If the backhaul network 100 operates in time division multiple access (TDMA), the RRM 106 may assign and reassign timeslots as a function of interference observed in particular timeslots. If the performance degradation is caused by another network using frequency hopping which is concurrently deployed in the vicinity of the network 100, the RRM 106 may change its frequency hopping pattern to minimize mutual interference.

[0023] When the RRM 106 recognizes that a WTRU 108 is interfering with a wireless backhaul link 112 between an AP 102 and the AR 104, the RRM 106 interacts with the AP 102 to mitigate the impact of the interference caused by the WTRU 108. For example, the RRM 106 may change operating frequency or other parameters on the wireless backhaul link 112 between the AR 104 and the AP 102.

[0024] Figure 2 shows a wireless communication system 150 including a plurality of networks 200, 300, 400 including at least one mesh network 200 and an RRM 500 operating in accordance with another embodiment of the present invention. The mesh network 200 includes a plurality of mesh points (MPs) 202_1-202_n. Each MP 202_1-202_n is wirelessly connected to at least one neighboring MP such that traffic may be routed via one or more hops through the network 200. The RRM 500 monitors performance on the wireless communication links 212_1 - 212_n in the mesh network 200 and dynamically changes operating frequency or other parameters on the wireless communication links 212_1 - 212_n between the MPs 202_1-202_n. For example, if the RRM 500 recognizes performance degradation in a particular link 212_1-212_n, the RRM entity may make measurements to find an alternative frequency with lower interference and forwards this information to relevant ones of the MPs 202_1-202_n to change the operating frequency for the link 212_1-212_n.

[0025] If the RRM 500 observes sudden traffic load increase between two MPs 212_1-212_n, the RRM 500 may change a routing algorithm to use two different frequency channels or links, instead of just using one between these two MPs 212_1-212_n to accommodate the increased traffic or may change the backhaul route through an alternative path in the mesh network.

[0026] In accordance the present invention, the RRM 500 coordinates multiple networks 200, 300, 400 such that when two or more networks 200, 300, 400 are deployed concurrently in the same proximity, similar rules can be applied. For example, the RRM 500 receives broadcast information about current resource usage of nodes in the network 400, for instance on a broadcast channel (BCH) in the wireless backhaul. Thus, another network accesses the information when it starts up in the same proximity and configures its parameters appropriately to avoid collision with the network 400.

[0027] As shown in Figure 2, the RRM 500 is in control of networks 200 and 300, but has no control over network 400. However, all broadcast information received from the network 400, (e.g., beacons), may be heard by a node in networks 200 and 300 and then forwarded to the RRM 500, (and the broadcast information can be heard by the RRM 500 itself, if it is a WTRU). Then, the RRM 500 would determine whether to take an action over at least one of networks 200 and 300. Thus, a high quantity of information is broadcast on the clear, (i.e., "active channel set" in beacon messages), and although a node is not part of the network that broadcasts the information, such information may be monitored to make better RRM decisions. Also, if the RRM 500 is in charge of more than one network, it can apply the same scheme to the other networks.

[0028] The broadcast information includes, but is not limited to, a timestamp reference, a service indicator, a load indicator, point coordination function (PCF) polling frequency, frequency channels in use, frequency hopping patterns or frequency assignment patterns and power settings. The broadcast of resource usage allows a concurrent network co-existing in the same proximity to schedule around it. The network may simply choose a different frequency channel to operate on.

[0029] The RRM 500 may configure one or many of the MPs 202_1-202_n in the mesh network 200 to broadcast the information in regular time intervals, or only when polled, or may send a unicast signaling message when requested or in an unsolicited manner to other nodes.

[0030] The coordination performed by the RRM may be performed in time domain, such as point coordination function (PCF)-based or hybrid coordination function (HCF)-based IEEE 802.11e extensions. For example, when first and second networks located in the same proximity have a contention free period starting at substantially the same point in time, the first network may allow the second network to initiate a polling procedure while the first network remains silent. When the second network finishes with all of its traffic, the first network may start to poll while the second network remains silent.

[0031] For example, the first network may poll its WTRUs every even 100 msec intervals, (e.g., 0 msec, 200msec, 400 msec, 600 msec, ...), while the second network may use odd 100 msec intervals, (i.e., 100 msec, 300 msec, 500 msec, ...), to poll its WTRUs. In this way, the two networks can avoid collisions and keep mutual interference low while still operating on the same frequency. This coordination may be performed via broadcast messages or a direct signaling between the two networks, (e.g., via the RRM 500).

[0032] Polling is a coordinated process for controlling transmissions over a wireless medium, as compared to contending for the medium upon need. The HCF polls specific stations to see if they have something to transmit and then it allocates Tx time if they so request. In accordance with the present invention, coordinated polling is implemented between two HCFs. For mesh networks, most of the control is not centralized but rather distributed. Thus, two coordinated polling sequences, (i.e., from two different coordinators, or from one coordinator to two different networks), may be used to avoid interference between two networks. In this way, the two networks can avoid collisions and keep mutual interference low while still operating on the same frequency. This coordination may be performed via broadcast messages or a direct signaling between the two networks, (e.g., via the RRM 500).

[0033] As shown in Figure 2, the present invention may be applied to multiple networks 200, 300 deployed concurrently in the same proximity, even if there is no direct communication between the networks. The networks 200, 300 may be any type of networks including networks deployed under different radio access technologies, (e.g., IEEE 802.11, IEEE 802.15, IEEE 802.16, cellular networks, or the like).

[0034] Where two or more networks 200, 300, are deployed concurrently in close proximity, the RRM 500 may run on all of the networks 200, 300. In such case, a hierarchy may be established for coordinating configuration changes of the networks 200, 300, (such as changing frequencies), where for instance backhaul links (or highly loaded links) would take precedence over lightly loaded links.

[0035] A common RRM 500 may be provided across the networks 200, 300, or a separate independent RRM 500 may be provided in each network 200, 300. For example, a common RRM 500 may be provided for IEEE 802.11 networks and IEEE 802.16 networks and for managing radio resources for the networks. The RRM 500 is not constrained to a single radio access technology, but rather it can coordinate multiple wireless networks, even if they use different radio access technologies.

[0036] Coordination may be performed across networks deployed under different radio access technologies, such as a cellular network and a wireless local area network under IEEE 802.xx standards. For example, actions may be performed by the RRM 500 to coordinate the load between two networks 200, 300, using one radio access technology and to take the redundancies of the network 400 that uses a different radio access technology into account. These actions could include for example the forcing of a change of channel, change of radio access technology, or the like, on specific WTRUs depending on the load conditions on all networks.

[0037] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the preferred embodiments or in various combinations with or without other features and elements of the present invention.

* * *

CLAIMS

What is claimed is:

1. In a wireless backhaul network including a plurality of nodes and at least one wireless transmit/receive unit (WTRU), a method of managing radio resources in the wireless backhaul network, the method comprising:

providing at least one radio resource manager (RRM) in the wireless backhaul network;

the RRM monitoring performance of wireless communication links associated with the nodes of the wireless backhaul network, wherein the RRM receives a quality report from each of the nodes in the network, the quality report including wireless backhaul link quality measurements and performance statistics; and

the RRM interacting with at least one of the nodes to mitigate the impact of interference caused by the WTRU if the RRM recognizes that the WTRU is interfering with a wireless backhaul link between two of the nodes and changes an operating frequency on the wireless backhaul link.

2. The method of claim 1 wherein the wireless backhaul network is configured in a point-to-point or a point-to-multipoint topology.

3. The method of claim 1 wherein the wireless backhaul network is configured in a mesh topology, each node being wirelessly connected to at least one neighboring node, whereby traffic may be routed one or more hops through the wireless backhaul network.

4. The method of claim 1 wherein the RRM resides in one of the nodes of the wireless backhaul network.

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5. The method of claim 1 wherein the wireless backhaul network further includes an access router (AR) which provides access to an access network, the AR comprising the RRM.

6. The method of claim 5 wherein the access network is a wide area network (WAN).

7. The method of claim 6 wherein the WAN is the Internet.

8. The method of claim 1 wherein at least one of the nodes is an access point (AP).

9. The method of claim 1 wherein the wireless backhaul network operates in time division multiple access (TDMA), and the RRM assigns and reassigns timeslots as a function of interference observed by the RRM in particular timeslots.

10. The method of claim 1 wherein the RRM changes a routing algorithm used to control traffic between at least two of the nodes.

11. A wireless backhaul network for managing radio resources, the wireless backhaul network comprising:

a plurality of nodes;

at least one wireless transmit/receive unit (WTRU); and

at least one radio resource manager (RRM), wherein the RRM monitors performance of wireless communication links associated with the nodes of the wireless backhaul network, receives a quality report from each of the nodes in the network, the quality report including wireless backhaul link quality measurements and performance statistics, and interacts with at least one of the nodes to mitigate the impact of interference caused by the WTRU if the RRM recognizes that the WTRU is interfering with a wireless backhaul link between two of the nodes and changes an operating frequency on the wireless backhaul link.

12. The wireless backhaul network of claim 11 wherein the wireless backhaul network is configured in a point-to-point or a point-to-multipoint topology.

13. The wireless backhaul network of claim 11 wherein the wireless backhaul network is configured in a mesh topology, each node being wirelessly connected to at least one neighboring node, whereby traffic may be routed one or more hops through the wireless backhaul network.

14. The wireless backhaul network of claim 11 wherein the RRM resides in one of the nodes of the wireless backhaul network.

15. The wireless backhaul network of claim 11 wherein the wireless backhaul network further comprises:

an access router (AR) which provides access to an access network, the AR comprising the RRM.

16. The wireless backhaul network of claim 15 wherein the access network is a wide area network (WAN).

17. The wireless backhaul network of claim 16 wherein the WAN is the Internet.

18. The wireless backhaul network of claim 11 wherein the at least one of the nodes is an access point (AP).

19. The wireless backhaul network of claim 11 wherein the wireless backhaul network operates in time division multiple access (TDMA), and the

AMENDED SHEET

RRM assigns and reassigns timeslots as a function of interference observed by the RRM in particular timeslots.

20. The wireless backhaul network of claim 11 wherein the RRM changes a routing algorithm used to control traffic between at least two of the nodes.

21. The method of claim 17 wherein the broadcast information includes a point coordination function (PCF) polling frequency.

22. The method of claim 17 wherein the broadcast information includes frequency channels in use.

23. The method of claim 17 wherein the broadcast information includes frequency hopping patterns.

24. The method of claim 17 wherein the broadcast information includes power settings.

25. In a wireless communication system including a first wireless communication network, a second wireless communication network located in the same proximity as the first wireless communication network and a radio resource manager (RRM), each of the networks including a plurality of wireless transmit/receive units (WTRUs), a method of managing radio resources to avoid inter-network interference, the method comprising:

the first network allowing the second network to initiate a polling process while the first network remains silent; and

the first network initiating a polling process while the second network remains silent, wherein the first and second networks avoid collisions and keep mutual interference low while operating on the same frequency.

26. The method of claim 25 wherein the first network polls its WTRUs every even 100 millisecond intervals, and the second network polls its WTRUs every odd 100 millisecond intervals.

27. The method of claim 25 wherein the RRM coordinates the first and second networks in time domain.

28. The method of claim 25 wherein the first and second networks have a contention free period starting at substantially the same point in time.

29. The method of claim 25 wherein the first and second networks use different radio access technologies.

30. A wireless network for managing radio resources, the network comprising:

a plurality of nodes;

at least one wireless transmit/receive unit (WTRU); and

at least one radio resource manager (RRM), wherein the RRM monitors performance of wireless communication links associated with the nodes of the wireless network, and the RRM interacts with at least one of the nodes to change a configuration on a particular one of the wireless communication links if performance on the particular wireless communication link falls below an established threshold.

31. The network of claim 30 wherein each node provides a quality report to the RRM, the quality report including wireless backhaul link quality measurements and performance statistics.

32. The network of claim 30 wherein the configuration is changed by using at least one of a different frequency band, a different time slot and a different frequency hopping pattern.

33. The network of claim 30 wherein the backhaul network is configured in a point-to-point or a point-to-multipoint topology.

34. The network of claim 30 wherein the backhaul network is configured in a mesh topology, each node being wirelessly connected to at least one

neighboring node, whereby traffic may be routed one or more hops through the network.

35. The network of claim 30 wherein the configuration is changed to use two or more links to accommodate load when a traffic load suddenly increases.

36. The network of claim 30 wherein the RRM resides in one of the nodes of the wireless network.

37. The network of claim 30 wherein the wireless network further comprises:

an access router (AR) which provides access to an access network, the AR comprising the RRM.

38. The network of claim 37 wherein the access network is a wide area network (WAN).

39. The network of claim 38 wherein the WAN is the Internet.

40. The network of claim 30 wherein the at least one of the nodes is an access point (AP).

41. The network of claim 30 wherein the wireless network operates in time division multiple access (TDMA), and the RRM assigns and reassigns timeslots as a function of interference observed by the RRM in particular timeslots.

42. The network of claim 30 wherein when the RRM recognizes that the WTRU is interfering with a wireless backhaul link between two of the nodes, the RRM interacts with at least one of the nodes to mitigate the impact of interference caused by the WTRU.

43. The network of claim 42 wherein the RRM changes an operating frequency on the wireless backhaul link.

44. The network of claim 30 wherein the RRM changes a routing algorithm used to control traffic between at least two of the nodes.

45. A wireless communication system for managing radio resources to avoid inter-network interference, the system comprising:

a plurality of wireless communication networks operating in the same proximity, each network including a plurality of nodes; and

at least one radio resource manager (RRM) for coordinating resources among the nodes of each of the networks, wherein the RRM monitors performance on wireless communication links of the networks, and the RRM interacts with at least one of the nodes to change a configuration on a particular one of the wireless communication links if performance on the particular wireless communication link falls below an established threshold.

46. The system of claim 45 wherein at least one node of one of the networks monitors information broadcast by a source within another one of the networks to make better radio resource management decisions.

47. The system of claim 46 wherein the broadcast information includes a timestamp reference.

48. The system of claim 46 wherein the broadcast information includes a service indicator.

49. The system of claim 46 wherein the broadcast information includes a load indicator.

50. The system of claim 46 wherein the broadcast information includes a point coordination function (PCF) polling frequency.

51. The system of claim 46 wherein the broadcast information includes frequency channels in use.

52. The system of claim 46 wherein the broadcast information includes frequency hopping patterns.

53. The system of claim 46 wherein the broadcast information includes power settings.

54. A wireless communication system for managing radio resources to avoid inter-network interference, the system comprising:

a first wireless communication network including a plurality of wireless transmit/receive units (WTRUs);

a second wireless communication network located in the same proximity as the first wireless communication network, the second wireless communication network including a plurality of WTRUs; and

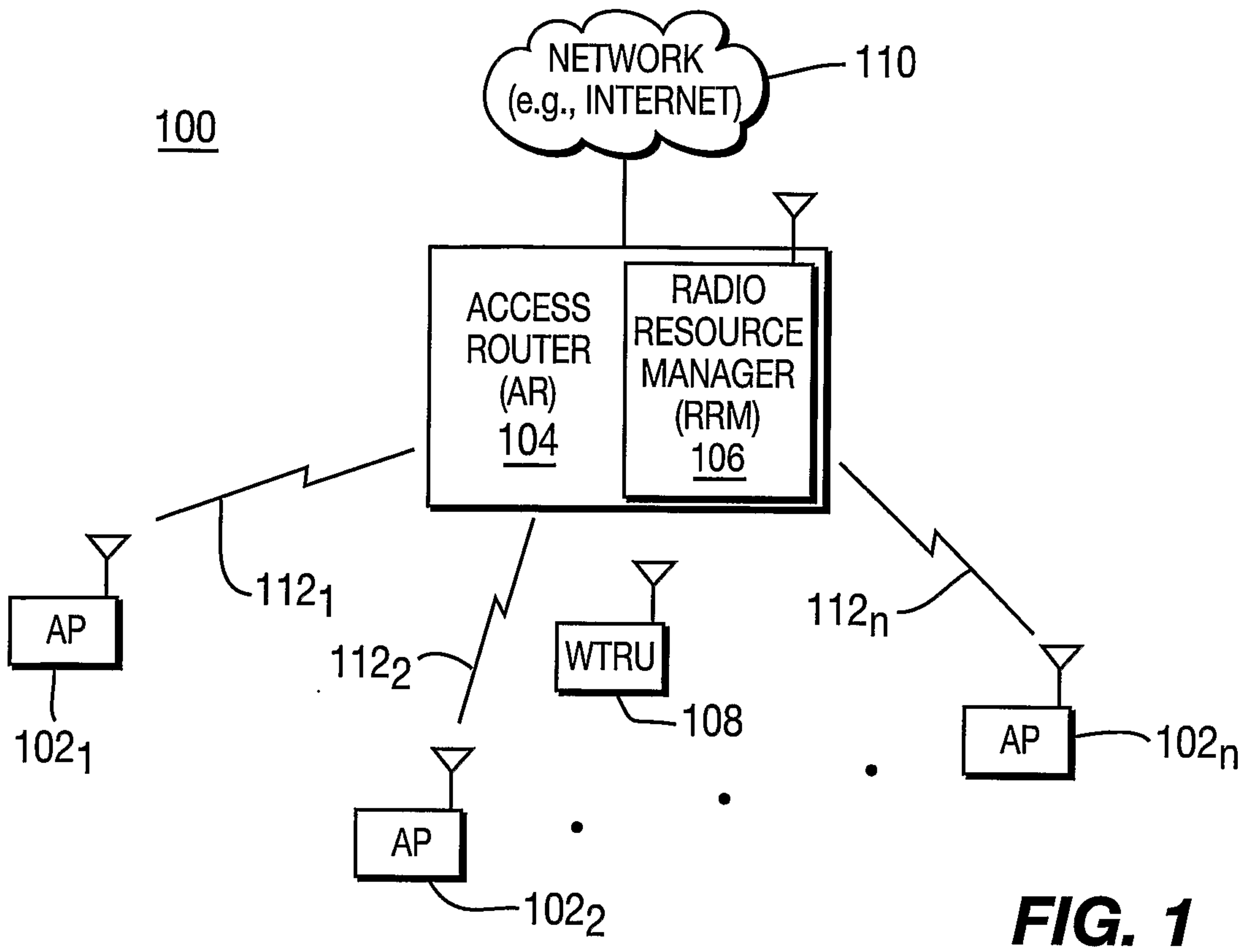
at least one radio resource manager (RRM), wherein the first network allows the second network to initiate a polling process while the first network remains silent, and the first network initiates a polling process while the second network remains silent such that the first and second networks avoid collisions and keep mutual interference low while operating on the same frequency.

55. The system of claim 54 wherein the first network polls its WTRUs every even 100 millisecond intervals, and the second network polls its WTRUs every odd 100 millisecond intervals.

56. The system of claim 54 wherein the RRM coordinates the first and second networks in time domain.

57. The system of claim 54 wherein the first and second networks have a contention free period starting at substantially the same point in time.

58. The system of claim 54 wherein the first and second networks use different radio access technologies.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ACCESS
ROUTER
(AR)
104
RADIO
RESOURCE
MANAGER
(RRM)
106
112_1
112_2
112_n
AP
102_1
WTRU
108
AP
102_n
AP
102_2

FIG. 1

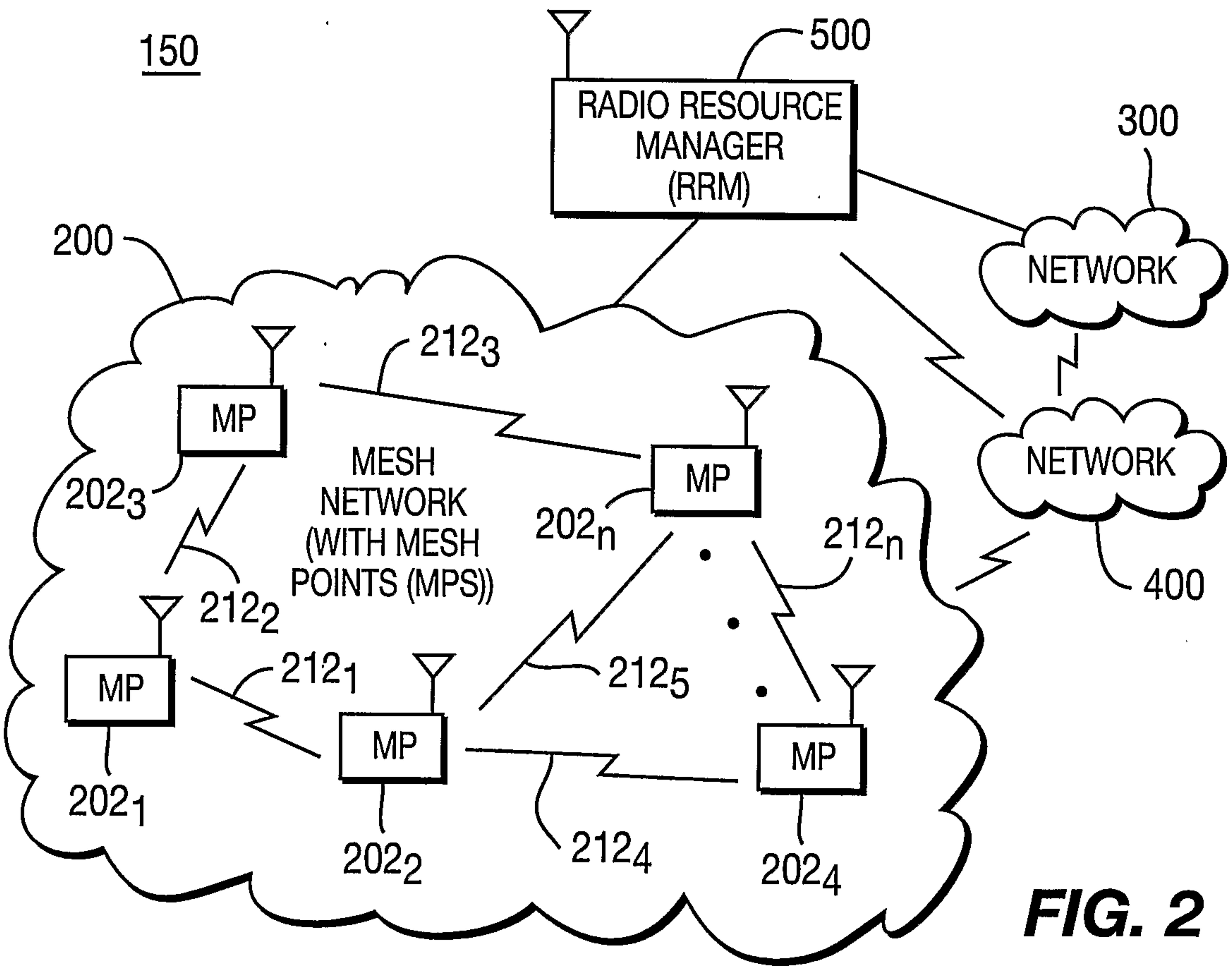
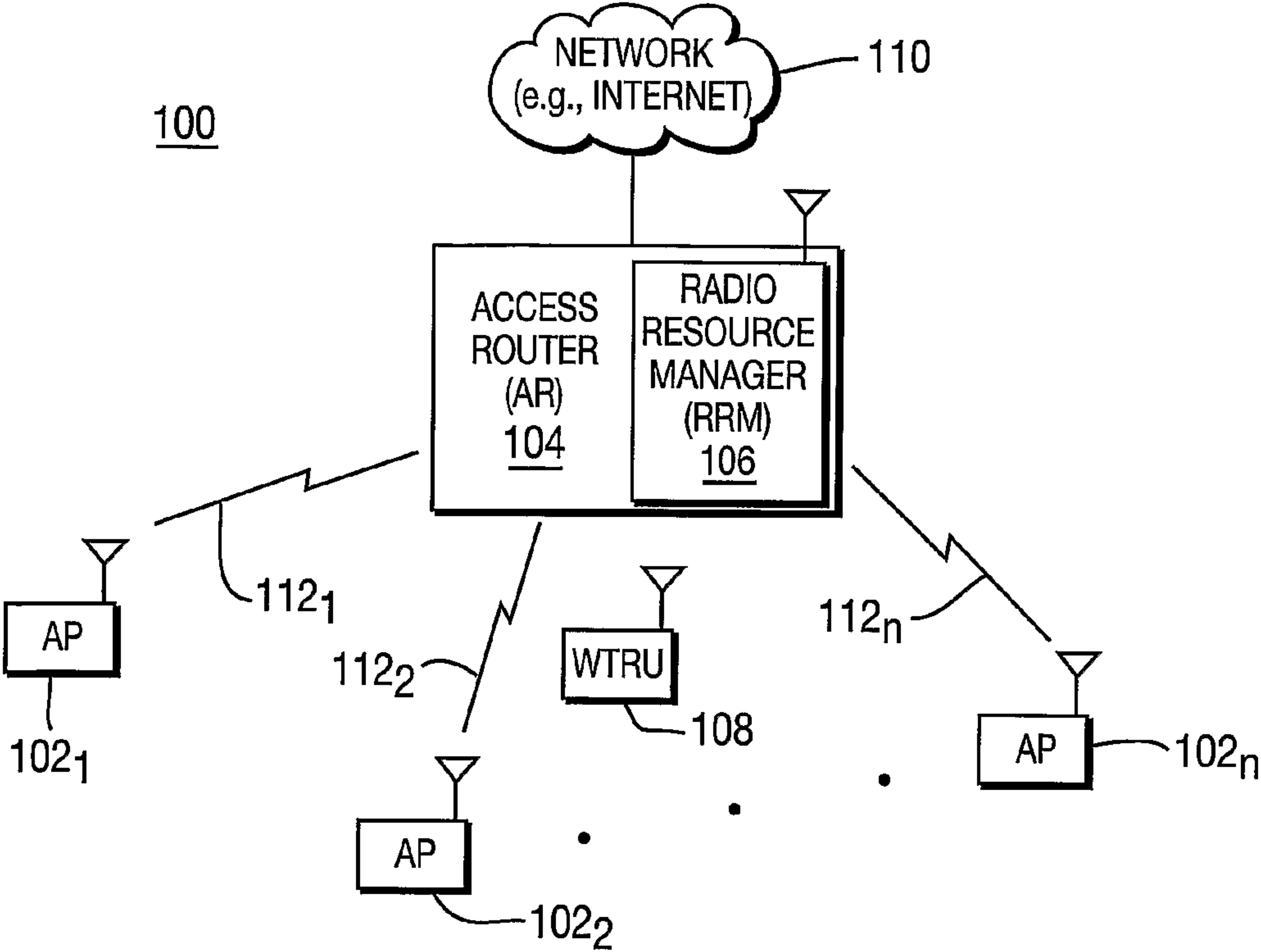

150
500
RADIO RESOURCE
MANAGER
(RRM)
300
NETWORK
200
212_3
MP
MESH
NETWORK
(WITH MESH
POINTS (MPS))
MP
202_3
202_n
NETWORK
212_n
400
212_2
MP
212_1
212_5
MP
MP
202_1
202_2
212_4
202_4

FIG. 2


NETWORK
(e.g., INTERNET)
110
100
ACCESS
ROUTER
(AR)
104
RADIO
RESOURCE
MANAGER
(RRM)
106
112_1
AP
102_1
112_2
WTRU
108
112_n
AP
102_n
AP
102_2