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Fifield

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(54) **WIRELESS NETWORK**

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(52) **U.S. Cl.** **370/345**; 370/329; 370/327; 370/437; 435/426; 435/447

(58) **Field of Search** 370/314, 337, 370/345, 346, 347, 350, 508, 445, 449, 468, 458, 474, 321, 329, 280; 455/426, 447, 66; 713/150, 160, 213; 320/337

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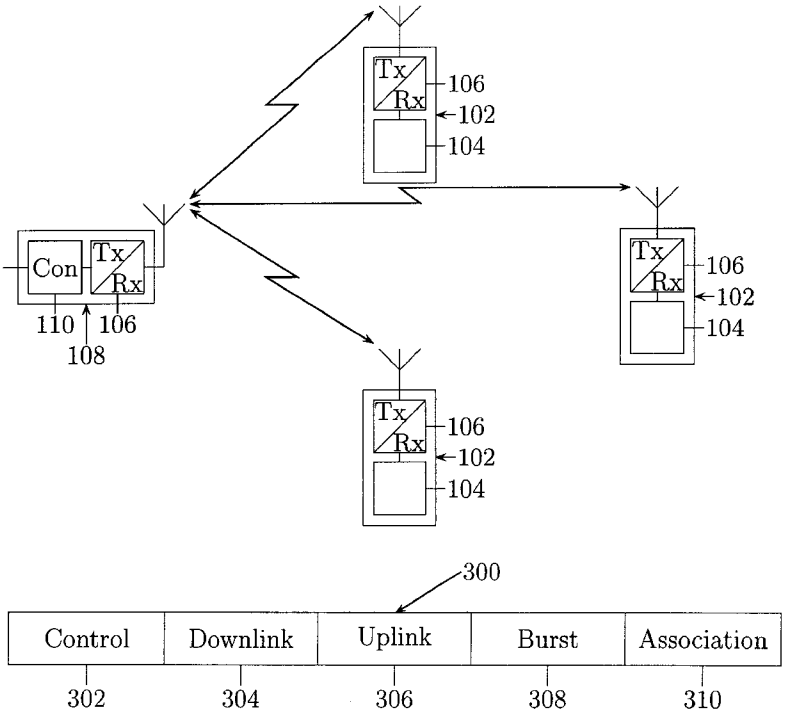
(57) **ABSTRACT**

A method of operating a wireless network comprising a plurality of wireless terminals and optionally a base station uses a transmission frame **(300)** including an association section **(310)** for use by wireless terminals wishing to join the network. A variable number of association sections **(310)** is scheduled in response to operating characteristics such as the load on the network or the presence of a high security application on the network.

10 Claims, 2 Drawing Sheets



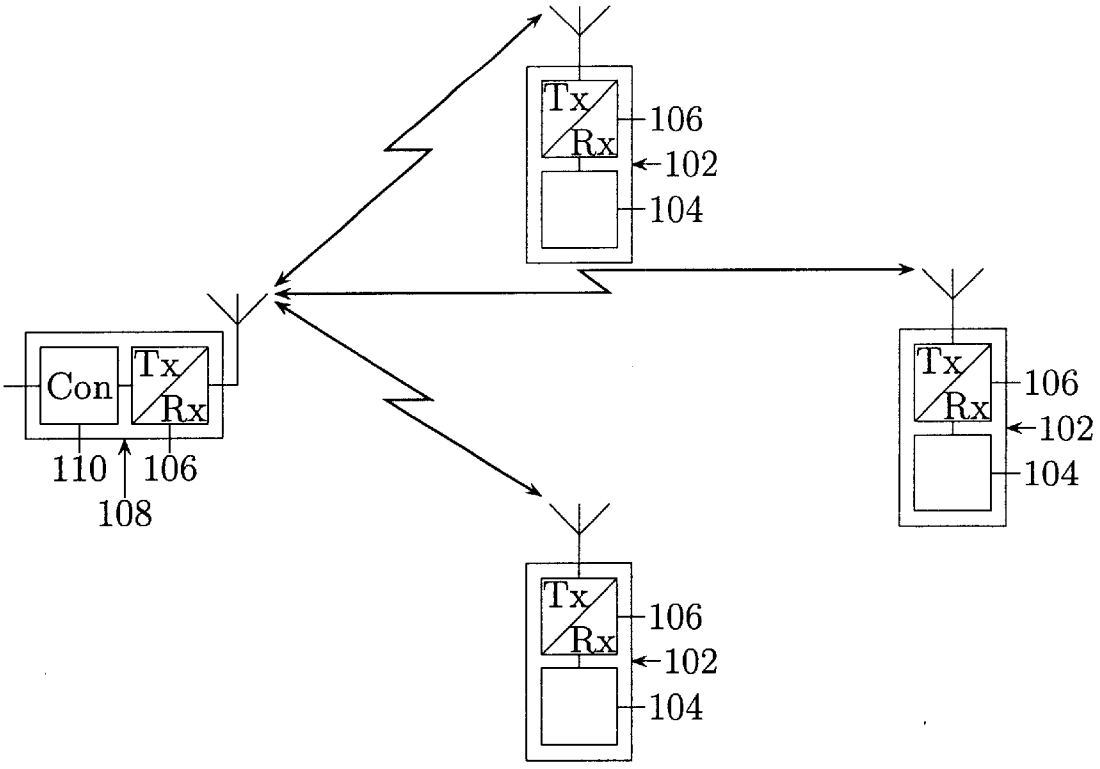


FIG. 1

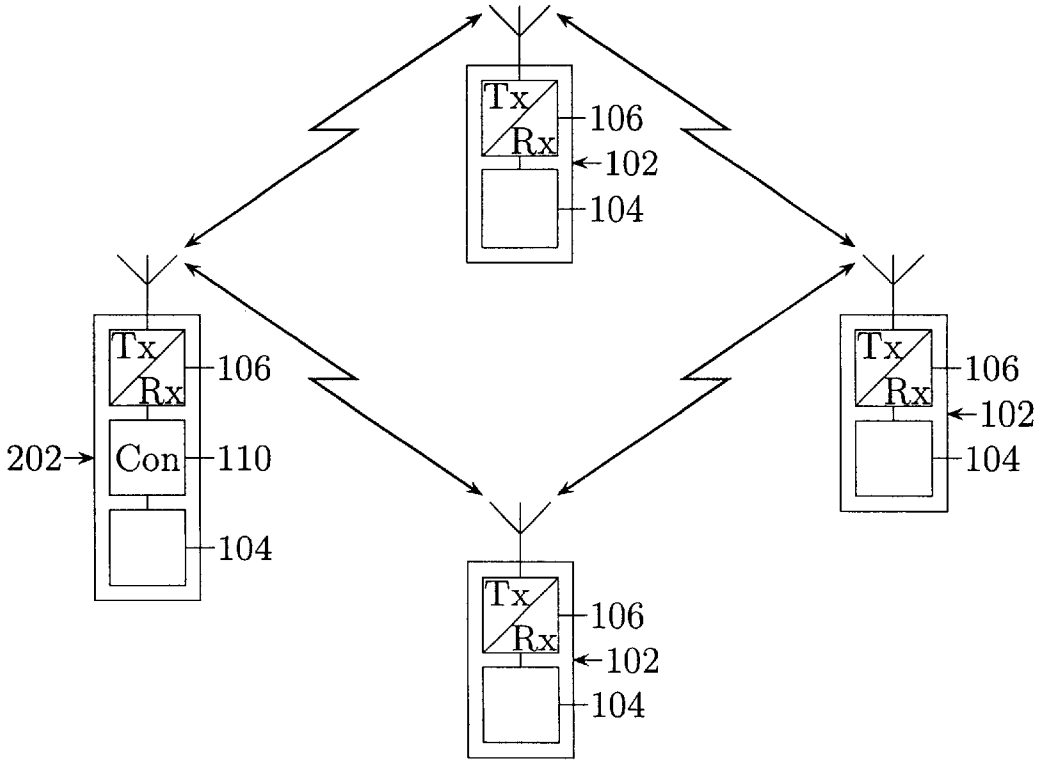


FIG. 2

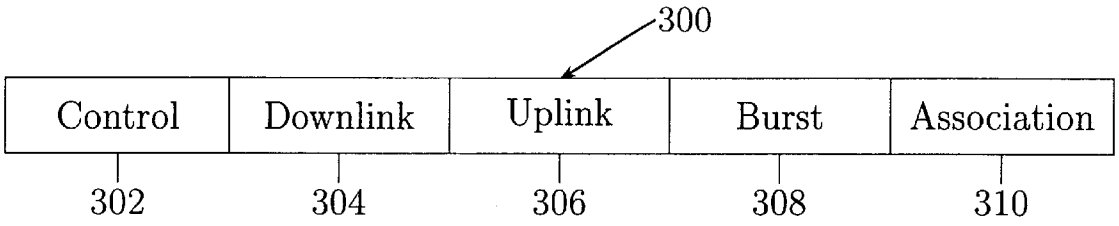


FIG. 3

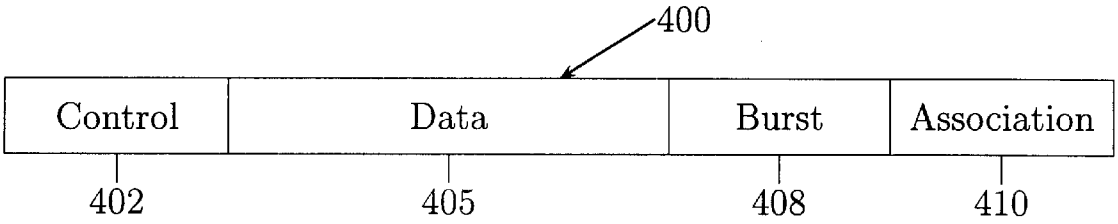


FIG. 4

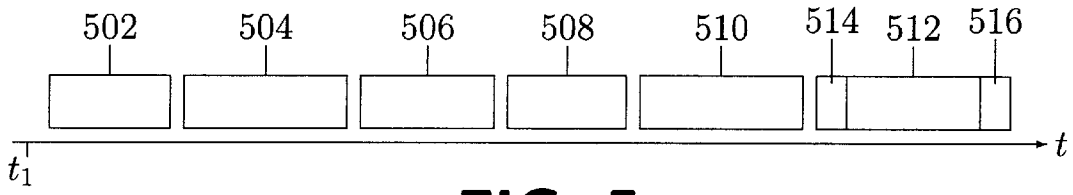


FIG. 5

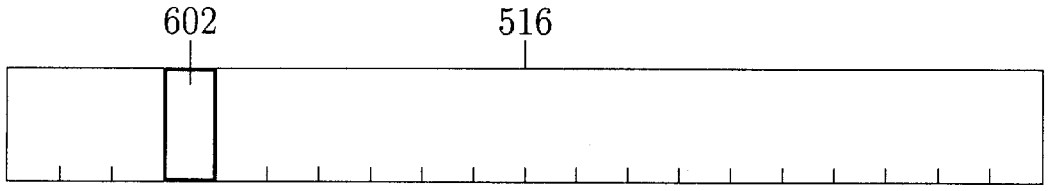


FIG. 6

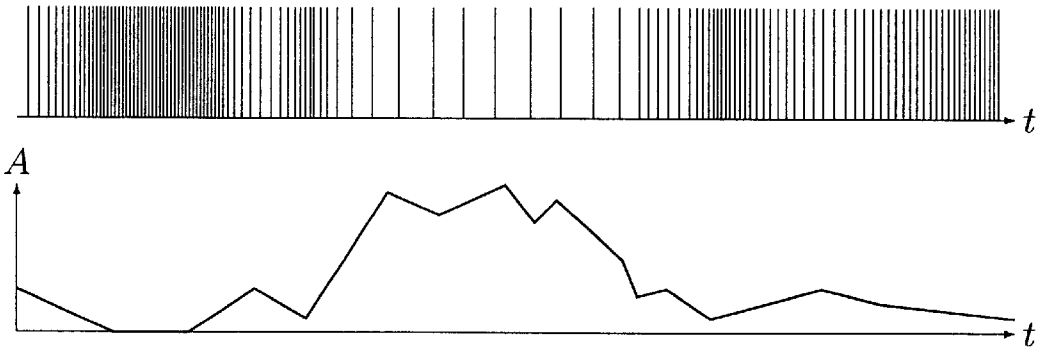


FIG. 7

WIRELESS NETWORK

BACKGROUND OF THE INVENTION

The present invention relates to wireless networks for communication between a number of wireless terminals which are free to join and leave the network at any time. The network may be configured so that all the wireless terminals communicate through a base station, or so that the devices communicate directly with one another.

Wireless networks are intended to offer flexible and cost-effective alternatives to wired networks, for example as Local Area Networks (LANs). An advantage of wireless over fixed networks is the ease with which new networks can be created and with which new devices, known as wireless terminals, can be added to the network. Some wireless network standards exist, for example IEEE 802.11 in the USA and HIPERLAN in Europe, whilst others are under development, for example Wireless Asynchronous Transfer Mode (WATM). Such standards define the format of a transmission frame, within which control and data transfer functions can take place. The format and length of transmission frames may be fixed or dynamically variable.

Known wireless networks, for instance as disclosed in U.S. Pat. No. 5,274,841, typically operate in one of two different configurations:

1 A base station orientated configuration in which wireless terminals can only communicate with each other with the support of a base station, which is responsible for all wireless terminals within a certain radio coverage area. The base station itself may be connected to further wired networks for communications beyond the radio coverage area. The base station may be a separate unit, or it may be a wireless terminal with additional functionality.

2 A peer to peer configuration in which wireless terminals communicate directly with one another. One of the wireless terminals is typically chosen dynamically to perform the control function.

The first configuration is generally considered to be most suitable for networks with a relatively fixed structure, while the second is considered most suitable for the generation of dynamic networks, such as for document exchange at a meeting.

In order for a wireless network to realise the advantage of flexibility, the procedure for wireless terminals joining and leaving the network should be as simple as possible. The act of a wireless terminal joining a network is known as association and needs to be scheduled within the data transmission format defined for the wireless network. Examples of known techniques for association include dynamic framelength slotted ALOHA, described in GB-B-2 069 799, carrier sense multiple access and address based tree resolution algorithms.

OBJECTS AND SUMMARY OF THE INVENTION

An object of the present invention is to improve the flexibility and efficiency of association to a wireless network.

According to a first aspect of the present invention there is provided a method of operating a wireless network, wherein transmission of data takes place in transmission frames of variable length subdivided into a plurality of time slots, the wireless network comprising a controller and a variable number of wireless terminals, the method comprising the controller maintaining a list of wireless terminals currently registered with the network, determining the lengths of successive transmission frames, and allocating time slots within said frame for various purposes, characterised by the controller scheduling a variable number n of association sections in each transmission frame, where n has a minimum value of zero, in response to the current operating characteristics of the network, by which association sections the wireless terminals can register with the controller.

If desired, the association sections may use a contention based protocol.

According to a second aspect of the present invention there is provided a controller for a wireless network having a plurality of wireless terminals, the controller comprising means for maintaining a list of wireless terminals currently registered with the network, means for monitoring the operating characteristics of the network, means for determining the lengths of successive transmission frames and means for allocating time slots within each of said frames, characterised by means responsive to the current operating characteristics of the network for scheduling a variable number n of association sections in each transmission frame, where n has a minimum value of zero.

According to a third aspect of the present invention there is provided a wireless terminal for use in a wireless network constituted by at least one wireless terminal and a controller, the wireless terminal comprising transceiver means for obtaining scheduling information relating to transmission frames in the network, characterised by means for determining whether an association section is available in a transmission frame and in that in response to said means the wireless terminal attempts association during the association section.

The present invention is based upon the recognition, not present in the prior art, that adding an explicit association section to a transmission frame format and enabling this association section to be scheduled more or less frequently depending on system load improves the efficiency and flexibility of operation of a wireless network.

By means of the present invention a wireless network can schedule a variable number of association sections dependent on considerations such as network loading and the number of active wireless terminals.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

FIG. **1** is a block schematic diagram of a wireless network made in accordance with the present invention, having a base station orientated configuration;

FIG. **2** is a block schematic diagram of a wireless network made in accordance with the present invention, having a peer to peer configuration;

FIG. **3** is a diagram of an example of a possible transmission frame format suitable for use in a wireless network configured with a base station of the type shown in FIG. **1**;

FIG. **4** is a diagram of an example of a possible transmission frame format suitable for use in a peer to peer configured wireless network of the type shown in FIG. **2**;

FIG. **5** shows in outline the process of a wireless terminal associating with the network;

FIG. **6** is a diagram showing an expanded view of the association section in a transmission frame; and

FIG. **7** in the lower half is a graph showing an example of the variation of network load with time (t) and in the upper half showing the corresponding scheduling of association sections.

In the drawings the same reference numerals have been used to indicate corresponding features.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The base station orientated wireless network shown in FIG. **1** comprises a number of wireless terminals **102** and a base station **108**, which base station is optionally connected to a fixed telecommunications network, for example the PSTN. The wireless terminals **102** comprise transceivers **106** which communicate with one another via the base station **108** which comprises a transceiver **106** and a controller **110**. The controller **110** may be at the same location as the transceiver **106** or remote from it and connected by land line connection means. A variety of devices may be configured to act as wireless terminals **102**, for example portable computers, printers and measurement equipment. In addition to the transceiver **106** each wireless terminal also comprises an application-specific block **104** which implements the required functionality.

The peer to peer wireless network shown in FIG. **2** comprises a number of wireless terminals **102** and an enhanced wireless terminal **202**, which comprises a transceiver **106** and application-specific block **104**, as for a standard wireless terminal, and further comprises a controller **110** to enable it to perform the control function in a wireless network if required. The wireless terminals **102** and enhanced wireless terminals **202** communicate directly with one another rather than via a base station. If there is only one enhanced wireless terminal **202** it performs the control function for the network, otherwise, one of the enhanced wireless terminals **202** is chosen dynamically to perform the control function.

The format of the transmission frame **300** shown in FIG. **3** is for a base station orientated configuration of the type shown in FIG. **1**. This particular format is intended for use with WATM and similar standards aimed at wireless local area networks. The format is a time division format comprising successive transmission frames **300**, where each transmission frame **300** is divided into a number of sections, each of which contains a number of slots in which data is transmitted. The lengths of the complete frames and the sections within them can be varied in response to changing requirements for data transmission to and from the wireless terminals **102**.

A control section **302** is used by the base station **108** to signal the allocation of slots to wireless terminals **102** in the sections comprising the remainder of the frame **300**. The allocation takes into consideration the number of slots requested by the wireless terminals **102**, the available bandwidth, restrictions on the length of transmission frames and any other relevant criteria.

A downlink section **304** is used for transfer of data from the base station **108** to wireless terminals **102**, the transfer of data to a particular wireless terminal **102** taking place in the slots allocated for it during the control section **302**. An uplink section **306** is used for transfer of data in the reverse direction, from wireless terminals **102** to the base station **108**. Again, the transfer of data from a particular wireless terminal **102** takes place in the slots allocated for it during the control section **302**.

An energy burst section **308** is provided for use by wireless terminals **102** that have associated with the network but are inactive. Each of these terminals is assigned a unique slot within the energy burst section **308** in which it may transmit to indicate that it requires an uplink slot to transmit data. The base station **108** will then take this request into account when scheduling the slots in the uplink section **306** of the next transmission frame **300**.

An association section **310** is provided for use by wireless terminals **102** that wish to join the network. The detailed working of this section is described below. The association section may not always be present, as it is scheduled under control of the base station **108**. The base station **108** may modify the scheduling of the association section **310** to:

- Schedule an association section **310** when it is convenient. This minimises the risk of losing transmission packets due to peaks in transmission traffic. Under conditions of high network traffic the base station **108** may not schedule an association section **310** in a transmission frame. In order to avoid completely shutting out new wireless terminals **102** the base station **108** may be controlled so that there is a maximum time delay between one association section and the next.
- Schedule association sections **310** more frequently during conditions of low network traffic. This allows faster association for waiting wireless terminals **102**.
- Schedule multiple association sections **310**. This may be desirable when many wireless terminals **102** wish to associate, for example if no association sections **310** have been scheduled for some time.
- Schedule no association sections **310**, which may be desirable in some special circumstances. One example when the network has no spare capacity, another example is when a high security application is running and wishes to prevent any further wireless terminals **102** joining the network.

It should be noted that the order of sections within the transmission frame illustrated in FIG. **3** may be varied, in particular it may be beneficial to schedule the energy burst section **308** and the association section **310** near the start of the frame to reduce transmission time delays.

The format of the transmission frame **400** shown in FIG. **4** is for a peer to peer configuration of the type shown in FIG. **2**, although much of the format is the same as for the base station orientated frame format shown in FIG. **3**. A control section **402** is used by the enhanced wireless terminal **202** acting as base station to allocate slots to wireless terminals **102** in the remainder of the frame. There are no separate downlink and uplink sections instead there is a data transfer section **405**, where transfer of data from one wireless terminal **102** to another occurs in the slots allocated to it, the reservation of which was detailed during the control section **402**.

The energy burst section **408** and association section **410** work in a similar manner to a base station orientated configuration.

Consider now in more detail the sequence of events occurring when a wireless terminal wishes to associate with a network, taking a base station orientated configuration as the example. FIG. **5** shows a sequence of transmission frames **502**, **504**, **506**, **508**, **510** and **512** transmitted over time t. Each frame has a format identical to or based on that shown in FIG. **3**, although the total length of the transmission frame **300** and the sections within it may vary. At time t_1 a wireless terminal **102**, identified subsequently as WTA, is switched on and wishes to associate with the network. The control section **302** of frame **502** indicates that no association section **310** is scheduled in this frame. The control

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