Attachment method in an ad hoc network; associated information recording medium, systems and nodes

The present invention relates to an attachment method in an ad hoc mobile network based on wireless cellular technology, and more particularly in a network of the type including a plurality of nodes, each node including an access point module, at least one relay terminal module. At each moment, the relay terminal module of a node is either not attached, or attached to a single access point module of another node of the network.

"Wireless cellular technology" refers to a technology as defined by the Wi-Fi standard, the WiMAX standard, the LTE standard or standards of the same type.

One such network is for example described in document EP 1,936,872 A1.

The relay terminal module (RT module hereinafter) of a first node is able to initiate an attachment process to the access point module (AP module hereinafter) of a second node selected from among the nodes situated in the wireless vicinity of the first node (i.e., in a coverage cell of the first node).

At each moment, the RT module of a node is either not attached, or attached to an AP module of another node of the network.

The AP module of a node is either not attached, or attached to an RT module, or attached to several RT modules.

Once an attachment is established, a two-way communication between the two attached nodes may occur. This attachment is ephemeral and may be broken at any time, either "voluntarily" by one of the nodes that "prefers" to attach itself to another node, or "involuntarily", when the attached nodes move away from each other and the quality of the established communication deteriorates or an obstacle disrupts the connection balance between the two nodes.

The network is formed based on the attachments between the nodes.

At a given moment, the network has a technology defined by a graph representing the nodes and the attachments existing between those nodes. Such a graph is for example shown in figure 1.

Each node can relay a communication between a source node and a receiving node exchanging data. Each node is thus capable of routing a data stream.

According to the prior art, in the attachment method, the selection of an access point from among the neighboring access points for the establishment of an attachment between two nodes is generally done as described below.

The AP module of each node periodically emits a beacon signal.

The RT module of a node periodically discovers its wireless environment by searching for beacon signals and updates a list of discovered neighboring nodes from information contained in the detected beacon signals.

Then, the RT module of the node selects the neighboring nodes to which it will initiate an attachment process either completely randomly, or based on a criterion, which may be a quality of the reception of the beacon signal, a predetermined hierarchy between the nodes of the network, a usage history of the network (the likelihood of attachment to a node for example depends on the number of attachments to that node in the past).

Once a neighboring node has been selected, the RT module of the node initiates an attachment process to the AP module of the selected neighboring node. The attachment process implemented between the RT module and the AP module depends on the cellular technology used. The selected AP module may respond negatively to the attachment request from the RT module.

However, the decision made locally by an RT module to select a neighboring node for an attachment does not necessarily lead, at the network scale, to obtaining a maximum overall connectivity.

For example, the network can be subdivided into several sub-networks or components, independent of each other, although a node of one component is within range of a node of another component, and by establishing an attachment between those two nodes, better network connectivity could be obtained for the network in its entirety. In the figure, nodes 1 to 3 belong to a first component R1 of the network R, while nodes 4 to 12 belong to a second component R2 of the network R. No node of the first component can communicate with a node of the second component. However, nodes 3 and 4 are within range. If an attachment existed between those two nodes, the overall connectivity of the network would *a priori* be improved as a result, the number of pairs of nodes able to communicate with each other increasing.

Also for example, the attachments between the nodes of the network can lead to the path followed by a data stream from a source node to a receiving node, within a component, being longer than necessary. Thus, in figure 1, in the second component R2 of the network R shown in figure 1, the path between the node 12 and the node 10 is relatively long. However, the nodes 11 and 8 are within range, and if an attachment existed between those two nodes, the path between the nodes 12 and 10 would be greatly reduced. The reduction of the average length of the paths participates in improving the overall connectivity of the network.

The invention aims to offset the aforementioned drawbacks, in particular by proposing an attachment method making it possible to improve the overall connectivity of the network.

The invention relates to an attachment method in an ad hoc mobile network based on wireless cellular technology, of the type including a plurality of nodes, each node including an access point module and at least one relay terminal module, a relay terminal module of one node being able to discover the access point module of neighboring nodes and initiate an attachment process with an access point module of a selected neighboring node, a relay terminal module of one node being attached at most to an access point module of a neighboring node, characterized in that it includes the following steps:

- at each node, acquiring a geographic position of the node and sending, via radio communication infrastructure, the acquired geographical position to a processing unit;
- at the processing unit, computing an optimal topology of the network by modifying the possible attachments between nodes considered to be neighboring based on their relative geographic position, selecting, from the optimal topology, for each node, the neighboring node to which the considered node must connect, and sending each node an identifier of the selected neighboring node; and
- at each node, commanding the relay terminal module of the node to initiate an attachment process to the access point module of the selected neighboring node indicated by the processing unit.

According to specific embodiments, the method includes one or more of the following features, considered alone or according to any technically possible combinations:

- the method includes, at the processing unit, after computing the optimal topology, the step consisting of selecting, for each node, the neighboring node to which it must connect, includes the determination, for each node, of the operating parameters allowing the relay terminal module of said node to establish an attachment to the selected node, and to send each node, in addition to the identifier of the selected neighboring node, the determined operating parameters; and, at each node, adjusting the relay terminal module of the node according to the operating parameters indicated by the processing unit, before initiating the attachment process to the access point module of the selected neighboring node.
- the method includes, at the processing unit, before computing the optimal topology, a step consisting of computing, for each node, a set of neighboring nodes with each of which the considered node may establish an attachment, a step consisting of determining, for each neighboring node of said set, operating parameters allowing the relay terminal module of the node to establish an attachment to the considered

neighboring nodes, and a step consisting of sending, to each node, the operating parameters determined for each neighboring node of said set; and, at each node, a step consisting of carrying out a discovery process limited to a domain corresponding to the received operating parameters and leading to the generation of a list containing the identifiers of the neighboring nodes actually detected; and a step for sending the generated list to the processing unit, at the processing unit, the step for computing an optimal topology of the network by modifying the possible attachments between nodes considered to be neighboring based on their relative geographical position and actually detected by the considered node as indicated in each received list.

- the geographic position includes an instantaneous position of the node and/or instantaneous course of the node.
- one operating parameter of the relay terminal module of a node is a channel number of a frequency band allocated to the network and/or an aiming direction of a means forming an antenna of the relay terminal module.
- the processing unit chooses a channel of an allocated frequency band on which the attachment between the considered node and the selected neighboring node must be made, and sends the selected channel to the relay terminal module of the node and the access point module of the neighboring node.

The invention relates to an information recording medium, characterized in that it includes the instructions for implementing an attachment method as defined above, when part of the instructions are executed by a computer of a node of the network and another part of the instructions are executed by a computer of a processing unit.

The invention relates to a system for implementing an attachment method as defined above, including a plurality of nodes, each node including an access point module, at least one relay terminal module, a relay terminal module of a node being able to discover the access point modules of neighboring nodes and initiate an attachment process with an access point module of a selected neighboring node, a relay terminal module of a node being attached to at least one access point module of a neighboring node, characterized in that it includes a service radiocommunication infrastructure, in that each node includes a communication module able to connect to said infrastructure, in that it includes a processing unit able to exchange messages with each of the nodes of the network via said infrastructure, in that each node includes a command module able to acquire a geographical position of said node and send the acquired geographical position to the processing unit, and in that the processing unit is able to calculate an optimal topology of the network by modifying the possible attachments between nodes considered to be neighboring based on their relative geographical position, selecting, from the optimal

topology and for each node, the neighboring node to which the considered node must connect, and sending each node an identifier of the selected neighboring node.

The invention relates to a node including an access point module and at least one relay terminal module, the relay terminal module of the node being able to discover an access point module of neighboring nodes and initiate an attachment process with a module of an access point of a selected neighboring node, the relay terminal module of the node being attached at most to one access point module of a neighboring node, characterized in that it can be part of a system as defined above.

The invention will be better understood, and other features, aims and advantages thereof will appear more clearly, using the following description of one particular embodiment of the invention, provided solely as an illustrative and non-limiting example, in reference to the appended drawings. In these drawings:

- Figure 1 diagrammatically shows the graph of an ad hoc mobile network based on wireless cellular technology;
- Figure 2 shows an embodiment of a system for implementing the method according to the invention;
- Figure 3 is a diagrammatic illustration of the structure of a node of the system of figure 2;
- Figure 4 is a diagrammatic block illustration of one embodiment of the method according to the invention; and
- Figures 5 and 6 are graphs respectively showing the evolution over time of the number of pairs of nodes able to communicate and the mean length of the paths in a network whereof the nodes implement the attachment method of figure 4.

The present attachment method is in particular advantageously implemented to form an ad hoc network using LTE ship-to-ship technology. The LTE technology for maritime applications takes advantage of the use of "directive" antenna-based transceiver means, for example of the type with a single, directive and directionally adjustable array using a mechanical positioner, or the smart type with a fast electronically steerable antenna, or FESA™, or the sectoral or multi-sectoral type.

The present method is thus implemented in a system, shown in figure 2, including a plurality of nodes according to the generic node i, shown in figure 3.

Each ship in a fleet is equipped with a node i, which is for example fastened on a mast of the ship.

The node i includes an AP module 20, an RT module 30, a control module 40, a positioning module 50 and a communication module 60.

The AP 20 and RT 30 modules are according to those of the state of the art.

In LTE technology, the AP module is an eNode B (evolved Node B) and the RT module is a piece of user equipment UE.

The AP module 20 includes a radio transceiver means for periodically emitting a beacon signal. The beacon signal is transmitted in a channel c_i of a frequency band allocated to the network R. That beacon signal includes the identifier i of the node.

When an RT module 30 of a neighboring node j of the node i has detected such a beacon signal and responds to initiate an attachment process, the AP module 20 of the node i is able to carry out the steps of the attachment process for which it is responsible. The attachment process is according to a protocol defined by the cellular technology used.

The RT module 30 of a node i includes a transceiver means forming an antenna requiring dynamic adjustment of a plurality of operating parameters.

In the following, the antenna is able to operate on a channel selected dynamically from among different channels fk of the frequency band allocated to the network R. The number fi of the channel on which the antenna of the RT module 30 of the node i must transmit and/or receive is an operating parameter.

Furthermore, the antenna is a directive antenna (within the meaning previously specified), i.e., able to aim in a direction that is adjustable in a substantially horizontal plane. This aiming direction is defined relative to a main direction corresponding to the course of the ship. The angle or the number of the angular sector of the main lobe of the diagram of the antenna, called relative bearing hereinafter, is an operating parameter.

When a discovery request is received, the RT module 30 carries out a discovery process. The discovery process indicates one or more pair(s) of operating parameters.

For each pair of parameters, the RT module configures itself, then executes a discovery process for its wireless environment, limited to the domain defined by those two operating parameters.

The RT module 30 is then able to discover the AP modules of the neighboring nodes j transmitting in the indicated channel and whose relative position with respect to the node i corresponds to the indicated relative bearing.

At the end of a discovery process, the RT module 30 is capable of updated a list Li of neighboring nodes j of the node i whereof beacon signals have been detected. The list Li includes the identifier j of a neighboring node, and values of the operating parameters used to discover it, namely the number of the channel fj and the relative bearing aj.

Upon receiving an attachment request, which includes the identifier j of a selected neighboring node and the operating parameters necessary to perform that attachment, the

RT module 30 of the node i is able, after configuration, to initiate an attachment process with that neighboring node j. More particularly, the RT module 30 of the node i is able to carry out the different steps of the attachment method with the AP module of the node j, according to the predefined protocol of the cellular technology used.

The positioning module 50 is able to deliver a geographic position and a course of the ship equipped with the node i. The positioning module 50 is for example a satellite positioning module, in particular of the GPS (Global Positioning System) type. Alternatively, the positioning module is shared between several systems of the ship and not incorporated into the node i.

The communication module 60 of the node i is able to connect the node i to a service radiocommunication infrastructure 70. The module 60 allows the exchange of service messages with a processing unit 80 via the infrastructure 70.

The control module 40 of the node i is able to apply, to the AP module 20, a request to generate a beacon signal, that request including the identifier i of the node as well as the number of the channel f_i on which to transmit that signal.

The control module 40 is able to apply a discovery request to the RT module 30, the request including the values of the operating parameters to be used to that end.

The control module 40 is also able to read the list Li of neighboring nodes j resulting from a discovery process carried out by the RT module 30.

The control module 40 is able to apply an attachment request to the RT module 30, the request including the identifier j of the neighboring node selected for an attachment, as well as the values of the operating parameters necessary to perform that attachment.

The control module 40 is able to acquire the instantaneous geographical position and course delivered by the module 50.

The control module 40 is able to transmit and receive service messages with the processing unit 80, via the communication module 60 and the communication infrastructure 70.

In the embodiment described here in detail, the communication infrastructure 70 includes a satellite component (satellite 72), the geographic coverage of which extends over the entire geographic zone within which the nodes i of the network R are led to move.

The processing unit 80 includes a transceiver means 82 making it possible to connect the processing unit 80 to the infrastructure 70. Thus, a communication can be established, via the infrastructure 70, between each node i of the network R situated in the coverage zone of the infrastructure 70 and the processing unit 80, to exchange service messages.

The method 100 is shown in figure 4.

In a first step 110, executed at each node i, the control module 40 acquires, from the positioning module 50, the instantaneous position Pi and the instantaneous course Ci of the node i.

In a step 112, the control module 40 acquires, from the RT module 30, the instantaneous status Ei of the current attachment of the node i with a node I, when such an attachment exists. The status Ei is for example a doublet including the identifier of the node I and the measurement of the quality of the connection established between the RT module of the node i and the AP module of the node I.

The control module 40 acquires, from the AP module 20, the number of the channel fi on which the beacon signals are transmitted.

Then, the control module 40 of the node i sends (step 114) the processing unit 80, via the communication module 60 of the node i and the service radiocommunication infrastructure 70, an identification message M1. That message includes the identifier i, the position Pi, the course Ci and the status Ei, when such an attachment exists, as well as the number of the operating channel fi of the AP module 20.

In step 120, the processing unit 80 collects the identification messages M1 coming from the different nodes of the network and updates the table T of the nodes present in the network R. The fields of the table T are the identifier i, the position Pi, the course Ci, the status Ei of a node i, as well as the number of the channel of the allocated frequency band that the AP module of the node i uses.

If the identifier contained in an identification message already exists in the table T, the other information in the identification message makes it possible to update corresponding fields of the table T.

If the identifier contained in an identification message does not exist in the table T, a new row is created in that table T. This makes it possible to account for a new node entering within the coverage zone of the satellite 72 of the infrastructure 70.

Periodically, from the table T, the processing unit 80 performs (step 130) a first computation consisting of determining, for each node i, a set Ui of neighboring nodes j with each of which the RT module 30 of the node i may establish an attachment.

This first computation is done by determining the relative geographic position between the node i and each other node j of the table T and only entering the identifiers j of the nodes located at a distance from the node i smaller than a threshold distance d0 (corresponding to the range of the AP and RT modules of the nodes).

For each node j of the set Ui, the processing unit 80 determines (step 132) the bearing angle aj from which the node j is "seen" by the node i and extract the number of the channel fj in which the AP module of the node j transmits beacon signals.

In step 134, the processing unit 80 develops and sends a discovery message M2 to each node i including, for each node j of the set Ui, the bearing angle aj and the number of the channel fj.

In step 140, the control module 40 of the node i receives a discovery message M2.

Consequently, the control module 40 applies (step 142) a discovery request to the RT module 30 by integrating the different channels fj and the different bearings aj indicated in that received discovery message therein, so as to facilitate the discovery process by limiting it to the operating domains in which a beacon signal may be discovered.

Thus, in step 144, the RT module 30 of each node i discovers its wireless environment by limiting itself to the channels and, for each channel, the bearing(s) indicated in the discovery request.

At the end of the discovery process, the RT module 30 generates a list Li of discovered beacon signals. The list Li includes the identifier of each node j whose beacon signal has been detected and, for each node j, the number of the channel fj in which the beacon signal has been detected, as well as the bearing aj under which the beacon signal has been detected.

In step 150, the control module 40 reads the list Li and builds a message of the detected neighbors M3 containing the information present in the list Li. The message of the detected neighbors is sent, via the communication module 60 and the communication infrastructure 70, to the processing unit 80.

In step 160, the processing unit 80 collects the different messages from the detected neighbors M3 coming from the different nodes i of the network R.

The processing unit 80 performs (step 162) a second computation designed to determine an optimal topology A of the network. That second computation is for example based on an optimization algorithm of the tree structure of the ad hoc network. Such an algorithm is known by those skilled in the art. The information contained in the lists Li returned by the nodes and indicating the neighboring nodes actually detected is used in that computation.

In step 170, from the optimal tree structure A, the processing unit 80 selects, for each node i, the neighboring node j to which the node i must attach itself. Furthermore, the processing unit 80 determines the operating parameters of the node i necessary to

establish the attachment to the node j: the channel to be used fj and the bearing aj to be used.

In step 172, the control unit 80 sends each node i of the network an attachment message M4 including the identifier j of the neighboring node to which the node i must attach itself, as well as the number of the channel fj to be used in order to establish the attachment and the bearing aj in the direction of which the antenna of the RT module must be aimed in order to perform an attachment.

In step 180, the control module 40 receives an attachment message M4.

In step 182, the control module 40 applies an attachment request to the RT module 30 such that the latter initiates an attachment process with the selected node j. The attachment request includes the values of the operating parameters of the RT module 30 (channel and bearing) making it possible to configure the latter in order to perform the attachment to the node j.

In step 184, the RT module 30 begins, according to the predetermined protocol, the attachment process to the node j.

In the following iteration of the method 100, the node i generates an identification message including the status of the attachment in progress. This information allows the control unit 80 to determine whether the attachment requested in the preceding iteration has been done correctly.

At a node of the network, the method 100 is initiated periodically by the control module 40 unless, between two "voluntary" performances, the RT module 30 indicates that the current attachment has been broken and that an attempt should be made to establish a new connection. In that case, once the attachment module 40 has received a request to break the current attachment, the control module 40 initiates the execution of the method 100.

By implementing the method 100, the neighboring node to which a node i is attached is selected by maximizing a global criterion at the control unit, the notion of proximity between nodes being determined by geographic positioning information sent by each node. This criterion for example consist of maximizing a cost function related to the connectivity of the network and the variables of which are, *inter alia*, the position information for each node i.

This criterion is global inasmuch as the computations pertain to maximizing properties relative to the entire network. It is different from a local criterion, where properties relative to a node are computed by the node itself. For example, although the attachment of a node i to a node j is not locally interesting for the node i, the processing

unit 80 may request that attachment and simultaneously request the attachment of a node k with a node l in order to globally achieve a maximal connectivity of the network.

In figures 4 and 5, graphs 400 and 500 respectively show the percentage of pairs of nodes able to exchange data and the mean length of the paths in an ad hoc mobile network based on wireless cellular technology implementing the attachment method 100 described above. These graphs result from a digital simulation of the evolution over time of the topology of the network, during movements of the different nodes.

According to this simulation, the implementation of the attachment method 100 makes it possible to obtain a network whose topology is optimal at all times.

This is in opposition with graphs 420 and 520, which correspond to a network in which each node implements an attachment method in which the selected node is chosen randomly from among the neighboring nodes.

Many alternatives of the attachment method and the system allowing it to be implemented can be considered.

Thus, other information may be taken into account by the processing unit so as to select what is, for a node i, the best node j in its neighborhood in terms of connectivity for the network in its entirety.

Other operating parameters may also be considered. Thus, for example, if the RT module of the node is fastened on a mast and is made up of two antennas with adjustable spacing, in order to obtain a vertical diversity and, consequently, optimal operation, then the spacing between those two antennas constitutes an additional operating parameter of the RT module that it may be interesting to adjust dynamically in order to improve the signal-to-noise ratio.

Also for example, the operating power of the transceiver means of the RT module is an adjustable operating parameter.

Of course, adjusting the operating parameters is advantageous, but not necessary. The method may in fact consist only of commanding the RT module of a node i so that it discovers its entire environment and generates a list of discovered neighboring nodes, that list next being sent to the processing unit so that the latter selects the neighboring node to which the node i must attach itself.

Alternatively, the processing unit also determines the channel on which the RT module of the node i and the AP module of the selected neighboring node j must establish the attachment. In fact, while the node i has discovered the presence of the selected neighboring node j on a first channel, it may be advantageous for those two nodes to establish an attachment, on a second channel. In this alternative, the processing unit [optimizes] the use of the frequency resource within the network.

Thus, after having selected the neighboring node j to which the node i must connect, the processing unit determines the channel fj to be used to do so. The processing unit sends an attachment message M4 to the RT module of the node i with the necessary parameters in order to perform an attachment, and simultaneously sends the attachment message M4' to the AP module of the neighboring node j, which includes the number of the channel fj' on which the AP module must now transmit beacon signals. The RT module of the node i detects those beacon signals in the new channel cj' and initiates the attachment process with the AP module of the neighboring node j on the channel.

Alternatively, the communication infrastructure includes, in place of or in addition to the satellite component, a plurality of base stations for example operating in a high-frequency radio domain (HF).

It should be noted that, for example for the case of an antenna with six facets able to operate in approximately ten channels, the discovery by the RT module of its entire wireless environment takes approximately several minutes (for example, 5 min). Thus, if the beacon signal is detected at the beginning of the discovery process, making it possible to determine the identifier j, the channel fj and the bearing aj of a neighboring node, it is likely that the information will no longer be usable several minutes later, after the end of the discovery process and when the attachment process is implemented with that neighboring node j, the node j having moved.

However, implementing the present method makes it possible to limit the domain (frequency and orientation) to be discovered and, consequently, to drastically reduce the time necessary for the RT module to carry out the discovery process (several seconds). The length of the discovery step being reduced, the instantaneous geographical position information delivered by each node will then be usable to determine the notion of neighborhood and to decide which node must attach to which other node.

CLAIMS

1.- An attachment method (100) in an ad hoc mobile network based on wireless cellular technology, of the type including a plurality of nodes (i), each node including an access point module (20) and at least one relay terminal module (30), a relay terminal module of one node being able to discover the access point module of neighboring nodes and initiate an attachment process with an access point module of a selected neighboring node, a relay terminal module of one node being attached at most to an access point module of a neighboring node, characterized in that it includes the following steps:

- at each node (i), acquiring (110) a geographic position of the node and sending (114), via a service radiocommunication infrastructure (70), the acquired geographical position to a processing unit (80);
- at the processing unit (80), computing (162) an optimal topology (A) of the network by modifying the possible attachments between nodes considered to be neighboring based on their relative geographic position, selecting (170), from the optimal topology, for each node (i), the neighboring node (j) to which the considered node must connect, and sending (172) to each node an identifier of the selected neighboring node; and
- at each node, commanding (182) the relay terminal module of the node (i) to initiate an attachment process to the access point module of the selected neighboring node (j) indicated by the processing unit.

2. The method according to claim 1, wherein:

- at the processing unit (80), after computing the optimal topology (A), the step consisting of selecting, for each node (i), the neighboring node (j) to which it must connect, includes the determination, for each node, of the operating parameters allowing the relay terminal module of said node to establish an attachment to the selected node, and sending (172) each node, in addition to the identifier (j) of the selected neighboring node, the determined operating parameters (a_j, f_j); and,
- at each node (i), adjusting (182) the relay terminal module of the node according to the operating parameters indicated by the processing unit, before initiating the attachment process to the access point module of the selected neighboring node (j).

3. The method according to claim 1 or claim 2, including:

- at the processing unit, before computing the optimal topology (A), a step consisting of computing (130), for each node (i), a set (Ui) of neighboring nodes with each of which the

considered node may establish an attachment, a step consisting of determining (132), for each neighboring node of said set (Ui), operating parameters (aj, fj) allowing the relay terminal module of the node to establish an attachment to the considered neighboring nodes, and a step consisting of sending (134), to each node (11), the operating parameters determined for each neighboring node of said set;

- at each node (i), a step consisting of carrying out (144) a discovery process limited to a domain corresponding to the received operating parameters and leading to the generation of a list (Li) containing the identifiers of the neighboring nodes actually detected; and a step for sending (150) the generated list to the processing unit (180);
- at the processing unit, the step (162) for computing an optimal topology (A) of the network by modifying the possible attachments between nodes considered to be neighboring based on their relative geographical position and actually detected by the considered node as indicated in each received list.

4.- The method according to any one of claims 1 to 3, wherein the geographic position includes an instantaneous position (Pi) of the node (i) and/or instantaneous course (ci) of the node (i).

5.- The method according to any one of claims 1 to 4, wherein one operating parameter of the relay terminal module of a node (i) is a channel number (fj) of a frequency band allocated to the network and/or an aiming direction (aj) of a means forming an antenna of the relay terminal module.

6.- The method according to any one of claims 1 to 5, wherein the processing unit (80) chooses a channel of an allocated frequency band on which the attachment between the considered node and the selected neighboring node must be made, and sends the selected channel to the relay terminal module of the node and the access point module of the neighboring node.

7.- An information recording medium, characterized in that it includes the instructions for implementing an attachment method according to any one of claims 1 to 6, when part of the instructions are executed by a computer of a node (i) of the network and another part of the instructions are executed by a computer of a processing unit (80).

8.- A system for implementing an attachment method according to any one of claims 1 to 6, including a plurality of nodes (i), each node including an access point module (20), at

least one relay terminal module (30), a relay terminal module of a node being able to discover the access point module of the neighboring nodes and initiate an attachment process with an access point module of a selected neighboring node, a relay terminal module of a node being attached to at least one access point module of a neighboring node,

characterized

in that it includes a service radiocommunication infrastructure (70);

in that each node includes a communication module (60) able to connect to said infrastructure;

in that it includes a processing unit (80) able to exchange messages with each of the nodes of the network via said infrastructure;

in that each node (i) includes a control module (40) able to acquire a geographic position of said node and send the acquired geographical position to the processing unit;

and in that the processing unit is able to compute an optimal topology (A) of the network by modifying the possible attachments between nodes considered to be neighboring based on their relative geographic position, selecting, from the optimal topology, for each node, the neighboring node (j) to which the considered node must connect, and sending to each node an identifier of the selected neighboring node in order to command the relay terminal module of the node considered to initiate an attachment process to the access point module of the selected neighboring node indicated by the processing unit.

9.- The system according to claim 8, wherein the relay terminal module (30) of each node (1) is adjustable based on operating parameters, and in that the processing unit (80) is able to determine, for each node, the operating parameters (fj, cj) allowing the relay terminal module of said node (1) to establish an attachment to the selected node (j), and to send each node, in addition to the identifier (j) of the selected neighboring node, the determined operating parameters.

10.- The system according to claim 8 or claim 9, wherein the processing unit (80) is able, before computing the optimal topology (A), to determine, for each node, a set of neighboring nodes with each of which the considered node may establish an attachment, and to determine, for each neighboring node of said set, operating parameters allowing the relay terminal module of the considered node to establish an attachment to the considered neighboring nodes, and to send, to each node, the operating parameters determined for each neighboring node of said set;

wherein each node (i) is able to carry out a discovery process limited to a domain corresponding to the received operating parameters and leading to the generation of a list of the neighboring nodes actually detected by the considered node, and to send the generated list via the processing unit;

and wherein the processing unit is able to compute an optimal topology of the network by modifying the possible attachments between the relay terminal module of a first node and the access point module of a second node that is considered to be neighboring based on its relative geographical position with respect to the first node and that has been actually detected by the first node.

11.- The system according to any one of claims 8 to 10, wherein the processing unit is able to choose a channel of a frequency band allocated to the network in which the RT module of one node and the AP module of a selected neighboring node must establish an attachment, and to send the selected channel to the RT module of the node and to the AP module of the selected neighboring node.