

The memory of the node N includes instructions of a computer program called a communication driver. These instructions are intended to be executed by the computing means so as to allow an application for example running on the other computer connected to the node, to communicate data on the network.

5 In particular, the execution of this driver gives the possibility of providing a node N with a broadcasting device 18.

As illustrated in Fig. 3, the broadcasting device 18 is at the interface between the means 40 for transmitting/receiving radio signals and a software interface means 50 allowing exchange of information with the other computer connected to the node N.

10 The broadcasting device 18 includes a control means for accessing the resource, a so-called MAC means 20 in the following, and a network coding means 30.

The MAC means 20 is able to apply a method for accessing the resource by dynamic containment, according to the one described in document EP 2 440 001 A1.

15 The MAC means 20 includes a module for receiving data packets from the means 40 for transmitting/receiving radio signals. This module is referenced by number 22 in Fig. 3. The receiving module 22 is able to extract the data contained in an incident packet (header and payload) and to transmit them by means of network coding 30.

20 The receiving module 22 is also able to extract parameters relating to the operation of the physical layer and to the quality of the packets received in the different time slots of the frames (packet collision, legible packet, etc.)

The MAC means 20 includes a collision reduction module 24. The module 24 is able to collect the parameters delivered by the receiving module 22 and to apply the method described in document EP 2 440 001 A1, in order to compute the transmission period Q for node N. This computation passes by estimating a number of neighboring nodes V.

25 The collision reduction module 24 is able to control the network coding means 30 and to pass on to it operating parameters such as a number of neighboring nodes V.

30 Advantageously, after having controlled the activation of the network coding means 30, the module 24 is able to receive from the module 30 parameters associated with the network coding mechanisms used. These are for example, the dimension of the field used for the coding algorithm, the threshold on the number of hops beyond which a piece of information is no longer propagated, or any other piece of information characterizing the network coding mechanism.

The module 24 is then able to take these parameters into account in the computation of the transmission period Q,

35 This allows in particular the module 24 to perform a computation of Q, different according to whether the information to be transmitted on the network stems from coding or

not. Indeed other communication services of the node N may use the MAC means 20, and in particular the transmission module 26: a point-to-point communication service, or else a point-to-multipoint communication service for example, which do not involve any processing by the module 30.

5 The MAC means 20 includes a transmission module 26 able to be called upon by the collision reduction module 24 at the beginning of the frame in which the node N is allowed to transmit.

10 The module 26 receives from the network coding means 30, a packet to be transmitted. The module 26 is able to randomly select the slot of the frame in which a packet may be transmitted. The module 26 passes on the packet to the means 40 for transmitting/receiving the radio signal so that the packet is transmitted in the allowed frame and the selected slot.

 The network coding means 30 includes a receiving stage 60, a storage stage 70 and a transmission stage 80.

15 The storage stage 70 includes an information table 72, a table of messages 74 and a matrix 76.

20 The information table 72 includes a first field for identifying each of the nodes of the network and a second information field including, when the relevant node N has not yet been able to decode the piece of information generated by the node corresponding to zero information, and when the relevant node N has succeeded in decoding the piece of information generated by the corresponding node, the decoded information.

 The table of messages 74 includes at line k a message M_k resulting from the combination of the pieces of information generated by the nodes of a list L_k .

25 Finally, the matrix 76 includes as many columns as there are nodes in the network 16. Line k of the matrix 76 includes, in the form of zeroes and ones, the list L_k of the nodes for which the pieces of information have been combined for constructing the message M_k of the table of messages 74.

 The receiving stage 60 includes a receiving module 62, a matrix reduction module 64 and a decoding module 66.

30 The receiving module 62 receives a packet P from the module 22 of the MAC means 20.

 The module 62 is able to read in the header of the packet P, the list L of the identifiers ld_k of the nodes for which the Infok pieces of information are combined in the message M contained in the useful payload portion of the packet P (Fig. 2).

When the list L includes a single identifier, this means that the message corresponds to a single piece of information. The module 62 is able to directly store this information in the table of information 72, at the line corresponding to the node identified in the list L.

On the other hand, if the list L includes several identifiers, this means that the message M results from the combination of several pieces of information. The module 62 stores the message M in a new line k of the table of messages 74 and adds a new line k to the matrix 76. This new line consists of "0s" for each node for which the identifier does not appear in the list L and of "1s" for each node for which the identifier appears in the list L.

The module 62 is then able to call upon the matrix reduction module 64.

The module 64 allows reduction of the matrix 76 and accordingly simplification of the table of messages 74.

The module 64 is then able to call upon the decoding module 66.

The decoding module 66 applies a decoding algorithm giving the possibility of solving all or part of the system of k equations with N unknowns formed by the matrix 76 and the table of messages 74.

If, at the end of the decoding, new pieces of information are isolated, the module 66 is able to store the latter in the information table 72.

The transmission stage 80 includes an encoder 82, a strategy selection module 84 and a packet generation module 86.

The encoder 82 is able to select $\underline{n}$ pieces of non-zero information in the table of pieces of information 72. The encoder 82 then generates a message M by performing a linear combination of the selected pieces of information. An "exclusive or" (XOR) operator is for example used on the pieces of information, in binary form.

The strategy selection module 84 is able to call upon the encoder 82 by passing on to it a series of variables.

The module 84 gives the possibility of indicating the value of the number $\underline{n}$ of pieces of information to be combined in the message M. For example, when the density of neighboring nodes decreases, the module 84 assigns the value 5 to the variable $\underline{n}$ and when the density of neighboring nodes increases, the module 84 assigns the value 10 to the variable $\underline{n}$. It should be noted that the current value of the variable $\underline{n}$ cannot be greater than the number of pieces of information contained in the information table 72 at the current instant.

The module 84 selects how the encoder 82 selects the pieces of information. For example, in the « random » selection mode, the encoder randomly selects $\underline{n}$ pieces of information in the table of pieces of information 72.

The strategy module 84 is driven by the collision reduction module 24 of the MAC means 20. The module 24 is able to estimate the number V of nodes found in its vicinity.

When this estimated number of neighboring nodes V increases, the module 24 increases the transmission period Q separating two frames during which the transmission module 26 is allowed to transmit a packet. It should be emphasized that the module 24 also informs the neighboring nodes on the value of the computed period Q so that they adapt the value of their transmission period. To do this, the module 24 controls the transmission module 26 so that it transmits suitable service messages.

When this estimated number of neighboring nodes V increases and for example exceeds a first number V_1 , the module 24 is able to request encoding of the pieces of information to be broadcast. The module 24 awaits the strategy selection module 84 which, in turn calls upon the encoder 82.

Preferably, the module 24 is able to communicate to the strategy module 84 the estimated number of neighboring nodes V .

Advantageously, after having controlled the coding of the pieces of information, the module 24 takes parameters into account which are provided to it by the module 30. These parameters for example deal with the properties associated with the network coding mechanisms, such as the coding type, the dimension of the field used, the threshold on the number of hops, or any other information characterizing the network coding mechanism.

The strategy module 84 is then able, from the value of the estimated number of neighboring nodes V , to define the operating variables of the encoder 82. For example, the module 84 determines that the number n of pieces of information to be encoded should pass from 5 to 10.

Finally, the packet generation module 86 of the transmission stage 80 is able to generate a packet from the message M obtained at the output of the encoder 82 and from the identifiers of the nodes, sources of the pieces of information combined in this message. The module 86 elaborates a packet according to the protocol illustrated in Fig. 2.

The packet generation module 86 places the packet in a buffer memory which the transmission module 26 of the MAC means 20 is able to read, with view to the next transmission.

As illustrated by Fig. 4, the operating method of the broadcasting device 18 is the following.

On the network R , the broadcasting service operates with a period for generating information. A service for synchronizing the nodes of the network gives the possibility of defining a common instant at the beginning of a period for generating pieces of information and a common instant of the end of a generation period. At the beginning of each generation

In parallel, the reception module 22 of the MAC means 20, collects parameters relating to the use of the radio resource and transmits them to the collision reduction module 24.

In an intermediate step 200, the module 24 estimates the number of neighboring nodes V. By computing the period Q, it defines the next frame in which the node N will be allowed to transmit a packet.

Next, during a transmission phase, the module 24 decides to resort to network coding of the messages to be broadcast, so as to reduce the number of packets to be transmitted and therefore the number of collisions.

In step 210, the collision reduction module 24 calls upon the strategy module 84 by passing on to it the estimated number of neighboring nodes V.

The strategy module 84 thereby awakes and launches execution of the encoder 82 by passing on operating variables to it. For example, the module 84 indicates to the module 82 that it has to operate in a random mode, by combining 10 pieces of information.

In step 220, the encoder 82 consults the information table 72 and randomly selects therefrom, 10 pieces of non-zero information, Info_m. The selected pieces of information are combined by means of an operation of the "exclusive OR" type so as to obtain a message M.

The encoder 82 transmits to the transmission module 86 the message M resulting from the encoding of the piece of information Info_m, as well as the list L_m of the identifiers of the nodes associated with each of the combined pieces of information.

Finally, in step 230, the packet generation module 86 elaborates a packet P, the header of which corresponds to the list L_m and the useful payload portion of which corresponds to the message M.

The thereby generated packet is made available to the transmission module 26. The latter has the responsibility of sending (step 240) the packet to the transmission/reception means 40 so that a suitable signal is transmitted in the allowed frame by the module 26, during a randomly selected slot by the module 26.

The broadcasting device shown above allows optimization of the traffic of packets while increasing by coding the number of pieces of information per packet and by reducing via containment, the probability of collisions between packets.

Alternatively, the module 84 is able to place the encoder 82 in a mode for limiting the number of hops of a piece of information from the node, the source of this piece of information. In order to apply this alternative, the header of the messages should include, associated with each identifier of a node, the source of a piece of information, the number of times that this piece of information has been relayed, i.e. the number of hops from the first broadcasting of this piece of information on the network. The information table 72 is then

CLAIMS

1. A node of a multi-hop ad-hoc radio network, the multi-hop ad-hoc radio network applying an information broadcasting service of a flooding type, according to which the node
5 broadcasts data packets to all of neighboring nodes thereof, said node comprising:

a controller accessing a radio resource by performing a dynamic containment for accessing the radio resource, wherein according to the dynamic containment, the access to the radio resource being subdivided into time frames, wherein the node is allowed to access the radio resource every Q time frames, wherein a value of integer Q being variable and
10 dynamically adapted according to a use of the radio resource made by the node and neighboring nodes thereof, said controller including a reception module, a collision reduction module and a transmission module, wherein:

the reception module extracts parameters relating to the radio resource and to a quality of data packets received from a radio receiver of the node;

15 the collision reduction module collects the parameters delivered by the reception module, computes the value of integer Q, and calls upon the transmission module at the beginning of the time frame in which the node is allowed to transmit; and

the transmission module selects randomly a slot of the time frame in which a
20 data packet is to be transmitted, and passes on the data packet to a radio transmitter of the node,

a network coder including a storage stage, containing information to be broadcast, and a transmission stage, the transmission stage preparing and generating data packets so that each packet includes, in a payload portion thereof, a message resulting from a
25 combination of a plurality of pieces of information to be broadcast, and, in a header portion thereof, a list of identifiers of each pieces of information combined, the transmission stage including a strategy selection module, an encoding module and a transmission packet generation module, wherein:

the strategy selection module selects a strategy defining how the encoding
30 module selects the plurality of pieces of information and generates the message,

the encoding module selects the plurality of pieces of information from the storage stage and generates the message by combining the plurality of pieces of information selected according to the strategy selected by the strategy selection module; and

the packet generation module generates a data packet from the message generated by the encoding module,

wherein the collision reduction module further passes at least one operating parameter on to the strategy selection module, the strategy being selected based on the operating parameter, the collision reduction module thus controlling the network coder in the generation of the data packets.

2.- The node according to claim 1, wherein the network coder comprises a receiving stage receiving data packets from the reception module of the controller, decoding the messages contained in the data packets received so as to update the plurality of pieces of information to be broadcast, wherein pieces of information are stored in the storage stage.

3.- The node according to claim 1 or claim 2, wherein the receiving stage includes a reception module, a matrix reduction module and a decoding module.

4.- The node according to any one of claims 1 to 3, wherein the storage stage includes an information table, and a matrix associated with a table of messages.

5.- The node according to claim 4, wherein the encoding module in the transmission stage of the network coder generates a message by linear combination of pieces of information selected in the information table.

6.- The node according to claims 4 or 5, wherein the encoding module randomly selects the pieces of information to be combined in the information table.

7.- The node according to any of claims 1 to 6, wherein said at least one operating parameter passed by the collision reduction module on to the strategy selection module is an estimated number of neighboring nodes.

8.- A method for broadcasting information in a multi-hop ad-hoc radio network, by applying an information broadcasting service of a flooding type at a node of the multi-hop ad-hoc radio network, the method comprising:

- selecting a strategy for encoding a plurality of pieces of information stored by the node and to be broadcast;- encoding, in a message, all or part of the pieces of information stored, based on the strategy selected;

generating a data packet which includes, in a payload portion thereof, said message, and in a header portion thereof, a list of identifiers of the pieces of information combined in said message;

transmitting the data packet generated by applying a dynamic containment process for accessing a radio resource, according to which, the access to the radio resource being subdivided into time frames, the node is allowed to access the radio resource every Q time frames, a value of integer Q being variable and dynamically adapted according to a use of the radio resource made by the node and neighboring nodes thereof, said dynamic containment process including, at a node of the multi-hop ad-hoc radio network:

extracting parameters relating to the radio resource and to a quality of data packets received from a radio receiver of the node;

collecting the parameters extracted, computing the value of integer Q; and at the beginning of the time frame in which the node is allowed to transmit,

selecting randomly a slot of the time frame in which a data packet is to be transmitted, and passing the data packet to a radio transmitter of the node;

wherein the method further comprises, during the dynamic containment process, the determination of operating parameters relating to the radio resource and to a quality of data packets received from a radio receiver of the node, and the step of selecting a strategy based on said operating parameters.