Proposition of a new MAC layer for wireless networks

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Abstract: - This paper details an original access method that can be used for all types of network using broadcast media (ad-hoc WLAN for example). This RNET protocol is a major development of the COMB method while bringing uniformity in the choice of codes and priorities. This method offers numerous advantages with respect to existing MAC layers: the determinist aspect, the guarantee of minimum bandwidth and resource reservations with the prior knowledge of the state of the network. This method is mainly interesting for home wireless LAN, for topologies based on a single cell, and/or multi-cell cover, for which it has also been adapted.

Key-Words: - wireless LAN, access method, TDMA, MAC, mobile communications, radio.

1 Introduction

The access methods to the media currently entrusted to layer 2 of the OSI model, and more precisely to the MAC (Medium Access Control) sublayer are one of the cornerstones of networks. It is mainly through their performance that LANs can offer high throughput, short access time and a low jitter… In view of the concurrent development of immaterial media like the radio or the infrared and given the relentless development of multimedia applications for Office Automation as well as real time applications for the industry, numerous access methods have shown their limitations. New investigations are underway in particular with standardisation organisations, to develop MAC layers yielding optimal characteristics.

The development proposed in this paper is part of these research works. The aim is to put forward an original distributed and determinist access method that can be employed in any type of broadcast wireless LAN. In addition to its use on a conventional wire bus, the RNET method is equally well suited to WLANs using immaterial media like the radio or the infrared. Also station mobility is taken into account. Based on a non-centralised and non-random protocol, RNET offers a high level of efficiency when it comes to using the channel ; going much beyond that of 802.3, 802.4, 802.11 or other networks. RNET is also well-suited to the applications that call for guaranteed minimum throughputs, low and bounded access times, that is typically real time and multimedia applications.

This protocol equally allows for automatic bandwidth reservations when a station asks to get into the traffic. If this is not possible, a warning is issued to inform the station about the network capacities. It can then choose between two options : either to make a new attempt or to give up.

2 Useful preliminary principles

The RNET protocol is reliant upon the following information.

2.1 The COMB method

Numerous access methods enable us to avoid collisions during transfers between several nodes in a network using a single channel at the same time. The specific MAC layer proposed in the RNET protocol is based in part on the use of principles known as the COMB method.

Assumptions for implementing the COMB method:

1- It is assumed that there exist N nodes in the LAN considered. Each one can at a given time use a single channel to transmit fixed length packets (or necessarily bounded packets).

2- Also, each node is assumed to listen to any other node (no hidden terminal). This assumption reserved for the presentation of the initial method will naturally evolve as the multicell wireless network method is customised (section 4).

3- It is assumed that concurrent transmissions on the part of several transmitters are synchronized or, in other words, that transmissions from different nodes start at the same time. This is essential as discussed in Section 2.2.

In the COMB method, each packet transmitted on the network is composed of two parts, as shown in figure 1:

- a priority code at the start of the message referred to as "COMB" code,
- the message itself.

Prior to any packet transmission, the transmitting node selects a COMB code among all authorised ones. The initial COMB method allocates these codes in a random manner to the transmitters several of which can therefore enjoy the same priority code at the same time.

In this paper, we propose a new code allocation method. This method is determinist and distributed.

A COMB code is created for a single T bit network (2^T defines the maximum number of nodes wishing potentially to transmit at a given moment in time). The BUSRT is the activity period of the COMB code that is, the presence in this code of a bit equal to 1. A silence is a period during which the COMB code is not active, when a bit in this code is equal to 0.

It should be pointed out that the notion of BUSRT and recessive bit exists in other domains as in industrial LANs (CAN for example).

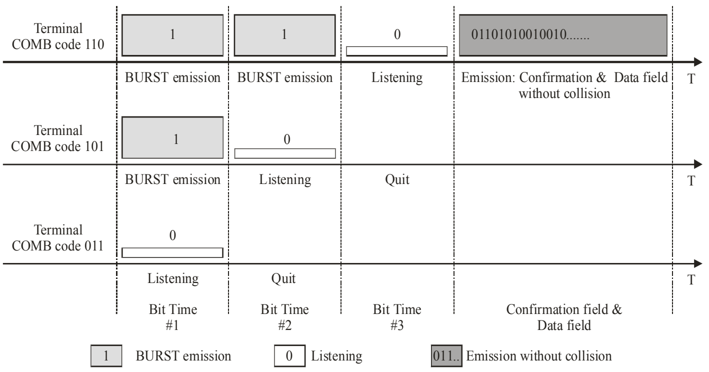

Fig.1: Example of the COMB method (without collision)

In the initial COMB method, when two or several transmitters attempt to access the traffic they generate each their own COMB code. This simultaneous transmission means that on a single bit medium dominating bits (1=BUSRT) and recessive bits (0=silence) compete. This takes place during the period of time reserved for the bit transmission (bit time). This period is as short as possible and depends on the physical characteristics of the medium.

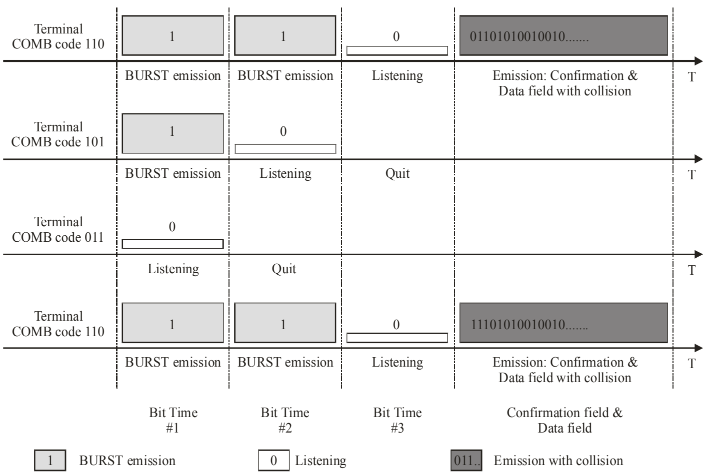

Fig.2: Example of the COMB method (with collision)

During transmission of a dominating bit, the transmitting node cannot conclude anything because its own transmission masks any other activity. On the other hand, if the transmitting node senses a BUSRT while transmitting a recessive bit it loses the contest for the channel and withdraws even before transmitting its own useful packet.

It may make a new attempt later according to a defined policy (Back OFF). At the end of the COMB T bit transmission, transmitter(s) with the highest priority COMB code can transmit their packet. The result of this arbitrage or progressive exclusion can naturally be obtained before the end of the transmission of any code, the competitors having less BUSRT can withdraw with the first code bits (as shown in figure 2 between COMB code 101 and COMB code 110).

If on the other hand, two transmitters or more use the same COMB code at the same time, they review the immediate listening of their code as an authorisation to proceed with the transmission, a collision is then taking place with the message field itself. This phenomenon is equally amplified if the code allocation priority is frozen between the transmitters.

Of course this method requires an adequate synchronisation between each bit of the COMB transmitted. In the sequel, we will present:

- a possible technique to obtain this distributed synchronisation,
- a different code allocation method for each transmitter at a given time,
- a fair method of network priority access allocation in time for each transmitter.

2.2 Distributed synchronisation

One of the most flexible solutions for the simultaneous transmission of competing packets is to perform a distributed node synchronisation using a synchronisation pattern .

The simplest case is that in which all stations are close that is when each one can dialog with any other. Each node generates its packet synchronisation clock indicating when it can transmit the start of each packet. It may be noted that to simplify the method all packets should be of the same size. Each node can listen to the packet clocks generated by the other. If a node detects that its clock is lagging behind the other clocks that it hears, it can speed up its transmitted clock and vice versa. According to the different control policies conducted it is fairly simple to obtain quickly a clock for all users.

In a topological environment corresponding to an ad-hoc wireless network (see equally fourth section), a station may not be close to the others. This remote station is then independent and uniquely synchronised on its own clock. If it moves towards the group of other stations it will gradually adapt its clock to synchronise it to that of the group (this is equally true conversely, but usually to a lesser extent).

Finally if two groups of stations (see later) come closer to each other to be within total or partial reach (resp., some stations together or all) the principle invoked previously remains true. Convergence towards a mean common clock is likely to be less rapid as a function of the number of stations. In addition, oscillation phenomena may appear that are well-known to automatic experts and that can overcome more complex clock control techniques based in particular on correction thresholds.

Of course, the particular case of stations moving away from the group is not a problem. One obtains as many clocks as there are independent groups.

For all intents and purposes, there exist in the literature technical solutions allowing for a set of nodes to be certain to talk at the same time and in sync. Therefore the bit to bit comparison of the COMB code is an assumption that we deem realistic.

It ought to be said as well that the accuracy that can be reached with these distributed synchronisation methods is adequate in terms of COMB bit width and limited dimensions of a LAN like the RNET.

2.3 Emission validity guarantee (ACK or confirmation)

Several principles allow a station to know whether the message it has just transmitted has been correctly received or if, at least, the frame has been correctly transmitted.

Numerous works have focused on methods naturally implemented in layer 2 of the ISO model. Without going too much into detail here, these methods are mostly based on an acknowledgement of receipt (ACK) issued against useful information.

The reception of an Acknowledgement is much more than a simple emission validity guarantee. Indeed, any ACK received allows to know whether:

- the frame transmitted has been correctly received,
- the ACK itself has been correctly transmitted,
- the ACK itself has been correctly received,
- the possible lack of the hidden terminal of destination,
- the absence of transmission error in both directions (measure of the link quality).

This scheme is much "too rich" for RNET but could nevertheless be employed. However, waiting for the ACK may in certain instances be penalising and it might be interesting to propose another technique which although not so rich in terms of information furnished is amply sufficient to verify what RNET needs, that is, only the transmission validity.

By "confirmation" we mean the immediate reception by a terminal of a pattern transmitted by itself. Each pattern is representative of a single terminal (it may consist of the frame that includes the transmitter source address).

- the correct reception of this pattern indicates that the information has been *transmitted* and *broadcast* on the network without collision.
- incorrect reception of this pattern highlights a collision with a message from another terminal.

If a transmission is "confirmed" , we say that the station has a 'Successful Packet' or SP.

Of course at this stage, the absence of collision fails to indicate the correct reception by the destination station of the information transmitted and broadcast.

3 The RNET method for monocell WLAN

In this section, we present the implementation of the RNET method on a general broadcast single cell medium (specific case of ad-hoc network). In the fourth section, we will describe that method more specifically for multicell wireless media (general case of ad-hoc network).

3.1 Basic theory for Z computing (Fig. 3)

- By "time position", we mean a specific instant when it is likely to transmit.

- By 'Z' or ' Z duration', we mean the time separating a 'Successful Packet' for a time position.

- By "set regime ", we mean the phase where each node having transmitted at least one "confirmed" packet that is a Successful Packet (SP), has been able to get into the traffic.

Z Computing (that is the different authorized positions) presented in this paragraph supposes that we operate under a set regime. Later the method required to reach this set regime will be presented.

This SP will be used as time basis for allocating several other time positions allowing for transmissions.

The station that intends to transmit has:

- an increased priority of success with each new time position allowed,
- uses the computational method for computing new time positions where it will be allowed to transmit.

The number of new positions allowed is directly linked to the number of bits of the COMB as described in Section 2.1.

A COMB exhibiting T bits allows for the computation of 2^T-1 new positions, only the value 00…..0 is not allowed since it is dedicated to another function that will be subsequently presented.

Each position is marked by a duration Z identical for all stations. With each duration Zi is associated a COMB code Ci, the couples (Zi, Ci) being constants identical for all stations. The position coming closest to the initial Successful Packet (Z being the smallest), is associated with the COMB code with the lowest priority (only the last COMB bit is dominant).

The furthest position from the initial Successful Packet is associated with the COMB code with the highest priority (T bits from the COMB are dominant).The furthest position (Zmax) enables the station to broadcast a new packet with

no risk of collision with another station. Indeed, the corresponding Z being computed from a SP from a single station, it is not possible for two stations (or more), to use the same COMB code at the same time.
The same reasoning is applied to the other computed Z.

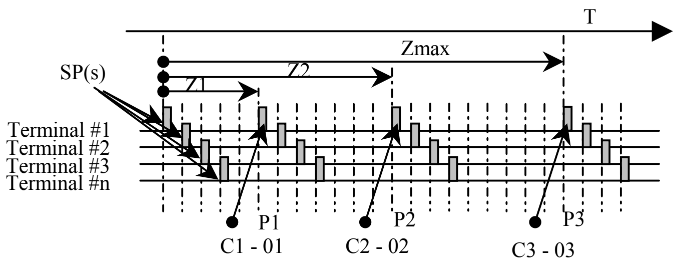

Fig.3: RNET protocol authorised positions

On the other hand, any station getting into the traffic which still uses at least its final position corresponding to Zmax, stays in the network. Thus it is guaranteed to stay in it without collision. If a station no longer uses a position it shall like any new station have to attempt an entry in the network once again.

3.2 Determinist method and guaranteed throughput

Under an established regime, the access method for the basic RNET protocol avoids collision between packets that are about to be transmitted by two different stations. Indeed, as seen in the preceding paragraph, it is possible that two stations (or more), have the same COMB code available at the same time.
Each station can equally guarantee the correct transmission of a packet within a certain amount of time. This time corresponds to the Zmax, associated with the highest priority COMB (with T dominant bits).
Two cases may occur:

- either the station has at least one packet to transmit before Zmax is reached, this packet is then transmitted "at the latest" to Zmax and the established regime shall be maintained
- or the station has no packet to transmit before Zmax. As the position associated to Zmax is not used, the station can no longer compute the positions allowed for this SP and is no longer within the established regime (except if it has other SP).

It may be noticed that is always possible to make a virtual use of the position Zmax to remain within the established regime and keep a minimum guaranteed throughput.
With respect to well-known techniques of random waiting time and firing (ALOHA, CSMA …) that desynchronise possible competitors the method proposed avoids collisions that are intrinsically absent. This native feature of the method proposed is innovating, especially for a fully distributed protocol and network not using an elaborated mechanism as the token bus.

3.3 The START method

In this section, we present the operation of the RNET protocol in its incipient phase: when a new station wants to send a packet and to have a SP. This "Successful Packet" allowing it to compute at a later stage the positions of authorised transmissions.
One may compare this state to the well-known state of standard 802.4, where a station intends to transmit frames but is not yet inserted in the logic ring and therefore has no right to speak.
The COMB code composed exclusively of recessive T bits (code 00..0) is reserved for stations that intend to transmit a frame but do not have (or no longer have) authorised positions computed from a previous SP. This special code is named the START code. Unlike the established model in which a station can only use its authorised positions, the START allows an insertion attempt in any position.
As this code is not priority, the station that intends to be inserted into the traffic must therefore wait for a position to be left vacant by the stations already occupying time positions. In other words, if the network is fully used, that is if the complete bandwidth is occupied, a new station cannot be inserted.
This self regulation is a specific advantage which is also intrinsic to the RNET since :

- no additional traffic can be accepted if the current traffic is maximum ; so the existing traffic is not disturbed,
- the candidate station is informed that it cannot get a SP.

On the other hand if other positions are still free, one station can increase its guaranteed throughput. Indeed, it is always possible to generate several additional START and thus, create new positions linked to the SPs obtained. When a new station attempts a START, it may not be allowed to do so and will have to repeat the operation usually as early as the next new position.
If on the other hand, no other station with a higher priority is detected during attempts, it features an empty position and transmits its packet while listening to and waiting for a confirmation. Listening is necessary because it may well be that one or several other stations are also attempting to obtain a SP at the same time. If a collision occurs between these new stations, each one will detect it through a lack of confirmation and make a new attempt later.
Here, several Back Off techniques may be attempted. The simplest consists in firing a random time prior to restarting. One may also imagine that waiting is proportional to the address of each station but this technique introduces priorities.
This waiting can equally be inversely proportional to the number of previous attempts leading to a fairer distribution of chances since stations have been trying to get into the traffic for a longer period of time and will be given priority over the last ones trying to get in.

Priorities based on classes of application or services can also be used.
It ought to be pointed out that CSMA type networks where stations attempt to get in at each transmission, the START function of the RNET network (and its Back Off) are only used at the time of entry in the network and therefore relatively infrequently. Therefore the RNET network can satisfy itself on a less sophisticated Back Off technique.

3.4 Entering the network: TRR

It is essential for a station wishing to get into the network traffic to know a priori the network capabilities (in particular the bandwidth available which it will use and before the station is effectively in the network).
One may consider that according to the traffic that has to be used, a user may be interested in the network possibilities even at the expense of delaying its exchange to avoid excessive costs or waiting times.
RNET allows this Test and Resource Reservation (TRR) in a very simple manner. A station wishing to get into the network uses the TRR function in lieu of the foregoing START function.
Unlike START, TRR does not compute the authorised positions from its SP (except for that corresponding to Zmax). A station wishing a particular bandwidth will use as many TRRs (and hence SPs) as necessary. If all these TRRs are accepted by the network, the station then knows that the desired bandwidth is possible. It can then use each one of the Zmax positions as it occurs this time naturally by computing the different positions allowed.
If, on the other hand, the station cannot get all the TRRs desired, the network cannot at the given time propose the bandwidth required. It can then either accept the bandwidth available or delay its traffic request pending an acceptable bandwidth. This process allows not to block pointlessly the network, while offering users the bandwidth resources most suited to their needs. If the protocol associated with a conventional START can be considered as a *Best-effort*, we can "compare" the introduction of the TRR to a connected mode (to the network and not to another station). To dispel any ambiguity on the very precise terms of the « connected mode » we prefer to use the expression « mode present on the network ».

3.5 Selection of the Z number

As all MAC protocols derived from the COMB code method, the RNET can be used with a different number of codes and therefore with a different COMB length. In a manner identical to the conventional COMB method, this number directly impacts the discrimination of concurrent stations to the channel access. It seems natural to think that the higher the number of bits (and therefore, the number of codes) the greater the chance for a station to access alone a channel at a given time.
An *a priori* ideal solution would be to have a number of distributed codes higher or equal to the number of stations in the network. However, this solution is rapidly reaching its limits particularly if the number of competing stations increases and the loss of time before each frame transmission automatically induces a loss of useful bandwidth (overhead).
The reasoning is somewhat different for the RNET which uses the COMB in a cleverer way. Indeed, by associating it as seen previously with a single position and not with a station at a given time, the number of bits T of the COMB code is directly conditioned by the possible number of authorised positions P. Thus position 0 being reserved for START, one gets: $P = 2^T - 1$ authorised positions.
If at a given time SP, it is interesting for a station to compute several new authorised positions, it is not, on the other hand, very useful to have many.
Indeed if it were the case, several positions would be remote in time and this is not necessarily interesting with regard to the transmission time limit and to the induced delay. In addition when a station is able to transmit successfully in a position close to its SP (where it is not certain to have the strongest priority), it enjoys another SP and a new computation of other positions without for all that losing the former positions it had computed from the former SP (recursively). Thus, a station usually enjoys a much more important number of positions ($> 2^T$-1) than the one computed from a single SP. It is not necessary to increase greatly the number of bits T of the COMB code, as the induced advantage (some additional positions that may not be used or that are too distant or identical since they have already been calculated) may not compensated by the loss of time resulting from a too long COMB code.
For example a 3 bit COMB seems to be a good tradeoff for a network of about 20 stations since it allows computation of 7 new positions for each new SP.

3.6 Choice of associated Zi values

The selection of Zi constants associated with each Pi position is important. Among these Zi, the value Zmax is particularly characteristic. Indeed, the proposed protocol is designed to insure a minimum basic throughput to each terminal. This throughput leads to a Zmax value corresponding to the maximum delay between two packets for the same station.
During computation of the new positions authorised from a new SP, it is essential for a station not to hit positions it already computed. If this rule is respected the selection of precise Zi values is not essential since the Pi positions computed by another station are likely to overlap with those of other terminals. Several computational laws for the distribution of Zi may be considered: first numbers, geometric series,… The equidistant Zi positions should naturally be avoided !

3.7 ReSTART

This principle is utilised in 'set regime' and may be considered as an established regime START that permits to add new resources to those already available.

ReSTART is used when a station with positions already computed considers that it has no immediate or near possibility of transmitting, when its next authorised position leads to a transmission delay deemed too long.

The station can then attempt to transmit a packet in a potentially empty position, even before its first authorised position. This is done as in the case of a START by associating code 0 with its transmission. Thus, it is not the priority, neither on broadcasts of code to higher priority (which is tantamount to saying that the position desired is detected as being occupied), nor on the other stations that attempt a START or a ReSTART like this station. Therefore, a risk of collision exists. If the station cannot transmit, it can attempt a ReSTART later or in the worst case it may have to wait for one of its authorised positions. If on the other hand it can transmit, it will have a new SP (with a shorter delay) which additionally grants it new positions.

An alternative to this ReSTART with the COMB code 0, may consists in a ReSTART with another code (1 for example), to avoid having to compete with other normal START, the ReSTART does enjoy priority over the latter.

On the other hand in this case, one consumes a COMB code (therefore new authorised positions computed from its related position). Indeed, this code is subtracted from those associated with authorised positions computed from a SP, which may be more detrimental than beneficial.

In all events, this ReSTART method allows to diminish the time delay before transmitting a frame for networks that are not too overloaded. For the overloaded networks, it will be extremely difficult to find a vacant position before its first computed position occurs.

3.8 START blocking

This optimization deals with to the possibility of START blocking by a specific station. If the latter senses that the network is about to be overloaded, it may prior to any saturation, block other requests (if any) for new resources issued by other stations by preventing them from performing a START (or TRR).

Blocking will then avoid network obstruction which would lead to detrimental transmission delays. This action consists in transmitting the COMB code "1" without the message or confirmation that follows. This blocking code "goes through" if at the same time there exists another identical code "1", or a code "0". Codes "0" (START or TRR) that are less of a priority do not go through thereby preventing any new resource allocation (the goal sought). One may note that the blocking code without message does not lead to a collision on the COMB code "1" messages.

The specific station will then transmit continuously (complying with the classical rules of transmissions governing the COMB method), and for the whole duration of blocking desired.

3.9 Substitution

Independently of the ReSTART, another optimization offer to a station, a greater number of new close and computed positions using a past position left vacant and replacing the station that could have used it.

First we present the principle based on a single distance D1. The aim is to use a vacant position that has been detected (*a posteriori*). If a station assigns this free position, it will be possible to compute new authorised positions that add to the others.

On the other hand, one has to avoid at all costs other stations doing the same thing and likely to lead to future collisions. To discriminate between competing stations during such a substitution, only the station with the desired free position at a distance D1 from one of its SPs is authorised. As each station knows this network constant D1, we can guarantee the uniqueness of the station in charge of the substitution.

Indeed, by definition there exists only one station associated with a SP, then only one station at a distance D1 from this SP. If the distance D1 is fairly short, most positions computed from the former vacant position will be beyond the present time. These positions will be added to the already computed positions of the station. This substitution principle will enable us to increase the number of positions and statistically reduce the transmission delay particularly when the network is not fully overloaded.

To avoid losing certain positions left vacant one can generalise the substitution principle to several distances D denoted D1, D2, D3 … (D1 being the shortest distance) ; indeed it is not necessary for the network to have a station that verifies the fact that it possesses an SP at a distance D1 from a position left vacant.

If D1 has not been used by a station to carry out a substitution, one reasons in terms of the distance D2 relative to that position left vacant. Likewise, D3 is used lies D1 and D2 could not be employed. This process is recursive and can be generalised to a great number of distances D.

Simulations have been carried out up to 17 different distances and have shown that more than 95% of vacant positions had been retrieved by active terminals. This substitution efficiency allows us to state that the sum of "calculated" positions by the terminals tend toward the constant Cmax close to maximum.

Without substitution, the number of computed positions depends on the traffic of the terminals (here the delay extends when the traffic diminishes). With substitution, the number of computed positions (directly or by substitution), becomes nearer of the greatest Cmax constant (independent of the traffic). The delay is equally a minimum constant which does not depend on traffic either. This delay tends to be highly stable.

3.10 Substitution based on non Z packets

When a station has a number of positions that it deems too important (eg, if it wishes to diminish its bandwidth, or if it pertains to a little demanding service class in terms of transmission delay or if it wishes to withdraw from the network correctly) it is equally possible to carry out a substitution based on so-called "non Z" packets.

The station cluttered by its positions doesn't calculate any other Z values for one or several SPs. It indicates it to the other stations by positioning a "non Z" bit in its SPs which by then have been stamped (and referred to as "non Z").

The stations wishing to perform a substitution can then do so starting from the positions left vacant as before but equally from "non Z" positions. This principle will allow a station to give the possibility to another one to compute positions on its behalf. This highlights the possibility with the RNET protocol to adapt dynamically the throughputs offered to the needs of some stations with a high time constraint by using the positions released by stations with a low time constraint.

4 The RNET method for multicell WLAN

The RNET protocol that we have presented can be used on any broadcasting medium where each node can listen to any other. This is the case of wire bus type medium and of all ad-hoc wire topologies where each station is within range of all others. To broaden the scope of the RNET application, enhancements and adaptations have equally been brought in for multicell WLANs. The solution proposed suits LANs with dimensions such that propagation time differences due to different lengths between possible paths within the network are negligible relative to the bit time. This is not a constraint because it is verified for distances in the order of a hundred meters (case of an indoor LAN for example) and throughputs in the order of the Mbps.

4.1 The mirror

The proposed solution will provide an optimal access method permitting a direct transfer without collision, from one Mobile Station (MS) toward a other specific MS. This specific mobile station is named Central Point (CP) or meeting point. This MAC transfer is offered to the upper LLC layer.

The central point echoes and propagates the COMB code information to all mobile nodes within range.

In the case of radio, the CP is considered as a specific mirror because it will lead to a frequency transposition between what it receives and what it retransmits. Indeed, it is impossible to assure instantaneous radio mirroring on the same frequency band. As a result we will use a frequency band U (up) for the ascending information transmitted from the mobile stations to a CP and a frequency band D (down) for descending information transmitted by the CP towards all the mobile nodes within range. By convention it is said that a reflection of X will be denoted X'. As can be seen in figure 4, three channels are provided for the two bands.

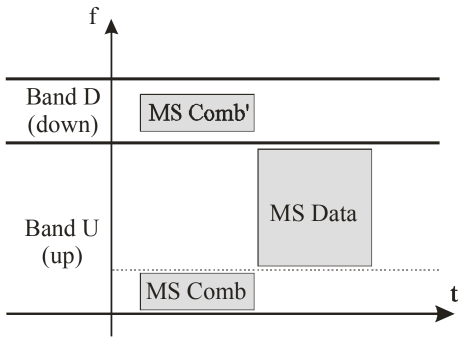

Fig.4: The two frequency bands used: U (up) and D (down)

- a MS transmits its COMB code by using the MS COMB code of band U.
- The mirror then reflects the COMB code received by using the MS COMB' code in band D.
- Useful data have an ascending channel in band U: MS Data.

In the particular case of a wireless LAN with infrastructure, the ideal mirror position is that of the base station representing the access point to the cabled backbone network. Each mobile station (MS) located in the basic station coverage area is therefore assured of being within range of the mirror and of a proper propagation of its COMB code to all the other stations in the network located in the CP cell as shown in figure 5. In our case of a wireless LAN without infrastructure (ad-hoc network), each MS which is present in the cell of several others stations must be a CP to insure the propagation process (the COMB code echo).

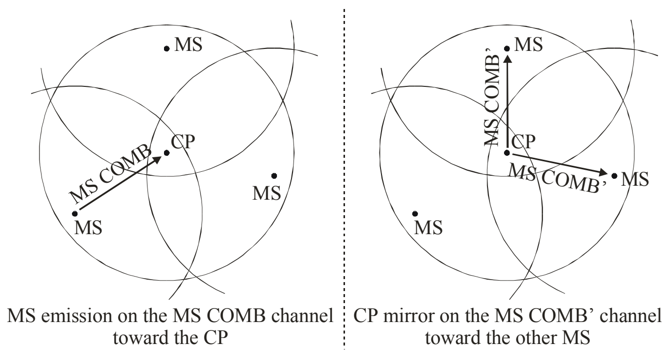

Fig.5: Use of the MS COMB code reflection mirror

4.2 COMB code propagation and Data relaying

When a MS want to send a message toward an other station, MS send first its COMB code by using the MS COMB channel in band U.

Each station which receive this COMB code is then considered like a CP. It generate this same COMB code by using the MS COMB' channel in band D. This mirror permits a good reception by all central points, without collision with emissions from other different stations. This echo assures the priority to the initial MS, even facing a possible hidden station that MS would not see but would disrupt the PC reception.
When the CP receive all the message with the data, it can know if it is itself the good destination of the frame. In this case, its MAC/LLC layer forward the information to the application or the upper layer. Otherwise, its LLC layer can relay this frame toward other mobile stations while using the same MAC principle. The PC is then considered like a SM, the other mobiles stations are considered like PCs.
In the LLC layer, different principles can be used for the cell relay : credit of jump, historic, TTL (Time To Live)... which are all compatible with the RNET MAC layer proposed for wireless multicell topology.

5 Conclusion

The specific features of the access method presented in this paper are due to the fact that while it is based on a distributed method, distribution in terms of medium access remains deterministic and mainly with a dynamic evolution permitting optimal use of bandwidth resources.
The very notion of reservation provides any user with a minimum service that may under certain conditions be improved over time.
The proposed optimizations, in particular, the ability to adapt to different classes of operation as a complement to the general method are only interesting, in specific operations and configurations. One may consider that the complexity of their implementation may be more cumbersome than beneficial. For example, a network configured with a large number of codes will not see its performance greatly modified by these optimizations. One may then think that the best optimization and also the simplest would be to use a maximum number of codes. However this results in a major overhead requiring a more delicate implementation particularly for wireless media
The proposed method is general in purpose and its wireless ad-hoc single cell implementation is natural. Likewise, its extension or implementation on a multicell ad-hoc or hybrid network can equally be envisaged [4].
Several simulations under Opnet [8] have been achieved and enabled us to verify the correct operation of this access method as well as its performances [9].
Prototypes were also manufactured by THOMSON on the initial versions of the protocols integrating the use of ramps [3], [2].

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