Slotted ALOHA Demand Assignment Multiple Access MAC Layer Description

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Introduction:

This note is prepared as a submission for evaluation by the MAC task group with respect to MAC requirements for IEEE802.11 standard. The details of this access method has been introduced previously. In addition, it also elucidates on two specific points which were raised on this method. However, the fundamental aim of this note is to provide descriptions adhering to the 21 guidelines produced by the MAC task group.

Review:

The slotted ALOHA DAMA MAC is based on a prime driver station or a dedicated node to provide the initial timing frame work whereby all participating nodes work within. This method is devised to satisfy a few of the following fundamental needs:

1) Graceful accommodation of increasing data traffic load beyond 10% and maintains operation at fixed efficiency at maximum traffic load.

2) Inherent isochronous operation.

3) Graceful expansion of service, from 2 node peer-peer operation to multiple network operation and from low cost minimum systems to high reliability systems.

4) Guarantee overlapping network operations by natural orthogonal isolation.

5) Time division method and prime driver station concept are implicit within infra red multiple network operation. This is because infra red technology is not mature enough to benefit from other isolation dimensions such as frequency or code.

The method can be simply summarized below:

A prime driver station transmits a timing frame with n timing slots. The means to transmit timing tic marks are simple and shall be ignored here. There are 2 overhead time slots. They are the ALOHA slot and the Broadcast slot and there are codewords to identify these slots. A station will detect the ALOHA slot, and make request for bandwidth. It then waits for bandwidth assignments in the broadcast slot. By monitoring the timing tics, it can take up its assigned bandwidth without contention.

As the bandwidth is demand assigned, there are great flexibility in adopting the assignment strategy to suit individual networks and propagation conditions. Furthermore there is no "hidden terminal" problem.

The detail discussion on this method can be found in previous IEEE802.11 submissions. However, there are the following modifications to this method so that the compromise between algorithmic implementation complexity and access efficiency can be made:

1) It is only necessary to synchronize all stations in a network. The need to synchronize all overlapping networks can be waived. The result is that a station entering a second network will have to suffer delay in re-synchronization. However, if one considers all other asynchronous access methods so far, all stations have to re-sync with every access. Thus the resultant delay statistics is still superior. The complexity of hardware is less severe even with minimum pre-amble overhead. It may turn out that the time tics alone are suffice for rapid re-sync.

2) The timing frame period should be adjustable with respect to traffic density. It is now recognized that in a low traffic environment, a short timing frame period with high overhead bandwidth to carrier bandwidth ratio will still maintain good data transport rate. Thus, in a typical IEEE802.3 type environment, where traffic density is < 18%, the short timing frame period will ensure Novell data packet be carried at minimum delay. It can be seen that the frame period selection can yield more favorable performance with Novell packet than uncoordinated access methods because the access delay is relatively stable. This is born from the fact that the ALOHA access request packet is smaller, thus the collision chances are much lower than a full data packet, given the same access population. Once the access is successful, the ACK is also guaranteed because it is pre-assigned, so the statistics of ACK collision is avoided.

The algorithm for timing frame to traffic density adjustment can be easily devised, and will be discussed at a later date if interest prevails.

When the data traffic increases and beyond 10%, normal uncoordinated access methods will reach infinite delay characteristics much sooner than demand assignment as it has been noted in previous submission. Furthermore, active stations with valid bandwidth assignment will still enjoy full capacity, and the same is not true otherwise.

In addition, the adjustable frame timing parameter will facilitate infra red PHY that rely on time domain isolation to share a common MAC.

3) There should be a shut-down restart state. This is when the prime driver station perceived the operable S/N condition cannot be maintained. A graceful shutdown-restart reset procedure is necessary. This requirement is peculiar only to RF propagation environment. The scenario is that when a mobile prime driver station with its network members encroaches on a stationary network, both networks will experience mutual interference. The reset state allows one to be aware of the other, and adopts suitable orthogonal isolation strategy. Many schemes for this strategy are viable and will be discussed at a later date if necessary.

4) During a slow traffic density period, the prime driver station will repeat all station traffic transmissions so as to provide added range and robustness. When the traffic density increases pass a certain threshold, all repeating processes will cease. In this case the range and throughput will be in line with the asynchronous access methods. It is reasonable that in a low traffic environment, the capacity is used to enhance range distance and to gain 2 times data repeat robustness. When the traffic density is high, it is also reasonable to cut out range. The station gets bandwidth but cannot be heard by the recipient station without repeating will not get ACK and shall then assume the recipient station is out of communications. The same station would have dropped out of communications at all time if it were using an asynchronous access method.

MAC Task Group List:

1) Unauthorized network access impact on throughput:

In an asynchronous access method, a persistent rogue station transmitting long packets will degrade network throughput directly by increasing collision statistics. Such is the case of "hidden terminals" and other variations of the same. A rogue station accessing ALOHA slot has much shorter requesting packet. The throughput efficiency impact is none although the access delay of all accessing stations will be affected.

It is necessary to investigate the rogue transmission probability statistics and its detection.

When a rogue station transmits in a Demand Assignment network, its first layer transmission instruction is its access request, which is a short message. There will be no data layer instructions until bandwidth is granted. Furthermore it needs synchronization prior to transmission. Thus, the opportunity for system level detection of a rogue transmission within the station is high, since the system level checking of network ID etc of the frame timing during synchronization is necessary. On the other hand, in an asynchronous access method case, the first layer transmission is a full data packet. Thus, the damage to the network efficiency is immediate.

2) Ability to establish peer to peer connection without prior knowledge.

Within a network, all stations listen to a Headend or prime driver station. Thus, after a prime driver station initiated frame timing structure for a peer to peer operation, it is certain that the recipient station must hear its transmission, if it is programmed to be in a network.

3) Throughput:

See previous submission. The throughput is a linear function of the traffic, if the traffic is less then the frame timing overhead, otherwise, it will be at constant maximum theoretical efficiency at high traffic.

4)Delays:
4.1 MAC to MAC delay:

ALOHA access delay + frame timing period (which at <10-18% traffic will be adjusted to minimum)+0 ACK delay (because the bandwidth is automatically assigned).

4.2. Propagation delay:

One frame period.

4.3.1 Transfer delay for datagram:

One minimum frame period (frame period is adjustable with respect to traffic). A minimum frame period can be designed to be as short as one desired. The efficiency is low because the overhead will be a good portion of the frame timing. However, in this case the traffic is also low <18%, so the effective throughput can be maintained to remain high.

4.3.2 High traffic.

In high traffic by frame timing definition will be at its maximum length, so the delay will be fixed at one maximum timing frame + slotted ALOHA access delay.

4.4 Overload.

At overload condition, the throughput will be at maximum efficiency, ie all bandwidth assigned, no slack time at all, which is unachievable by asynchronous means. Furthermore, no transmission repeats in high traffic will converge the traffic density by allowing stations with the best reception ie least error to remain.

4.5 MAC setup delay:

This is constant for stream and for burst.

5 Maximum number of stations

As uncoordinated station transmission will only happen for access requests, which is a short message, the traffic saturation probability with unaccessible collision contention is much less than if the uncoordinated transmission message length is long, as in the case of asynchronous access methods. Thus, the population of low traffic stations it can sustain is higher.

6) Ability to service isochronous traffic:

Demand Assignment method is optimized in isochronous traffic.

7) Transparent to PHY.

All PHYs which can transmit timing tics and have time domain isolation dimension are suitable.

8) Robustness with co-sited networks:

All networks with single dimension PHY will listen to one prime driver station so it prevents un coordinated interference. Multiple dimension networks (ie code /time /frequency isolation) can coexist as far as the isolation limits allowed.

9)Power Consumption:

Prime driver station has to maintain time tics. Thus it cannot remain silent. Pseudo Headends should only maintain tics when communications is in progress. Node Headend has no power consumption problems as it is stationary and permanent.

10)Any critical delays which limits large area coverage.

The modifications mentioned above to dispense with inter-network synchronization will eliminate any restrictions on area size. However, by doing this, the inter network communications will require re-synchronization. It would put the inter network delay to be at par with asynchronous access method requiring acquisition overhead.

11)Fairness of access

As per slotted ALOHA. Capture effect exists.

12)MAC need to enforce capture effect

The capture effect is much less pronounced here because, once a station gains access, it is bandwidth assigned, and out of the accessing population. The statistics is different for asynchronous access method because accessing function is a continuous one for every packet.

13) Support for priority

After a successful access, the bandwidth priority is configurable.

14)Ability to support one way traffic:

Since the bandwidth is a configurable entity here, the network can assign its bandwidth without ACK slots, or in the broadcast slot inform stations not to expect ACKs. For instance, in a peer to peer environment, a station starts a timing frame and assigns itself bandwidth. It knows all stations in the network will listen, so it needs not assign an ACK slot to invite recipient station to reply. In a Headend environment, the same thing can happen.

15) Time to market.

Synchronized RF modem is a lot simpler to design. It has a lot of time to acquire sync and wait for data to appear. All oscillators will be locked, thus frequency stability is not a great concern. This is not true in asynchronous case. In this case you require a good burst demodulator which can acquire carrier and bit timings from burst to burst. Frequency stability is very stringent if the overhead preamble is short. High speed, high performance (ie: low preampble overhead, low false detection rate and with continuous mode BER statistics) burst demodulator design remains a private proprietary art which has very few public literature available.

16) Ability to work in systems.

See previous submissions. This is one of the basic reasons that this access method is devised. It can work on a low cost system and interoperable to expensive systems where human lives may rely on the robustness of the network. In another word, one can purchase a low cost unit, and may expect to lose connectivity from time to time. One can also design an expensive unit so that connectivity will always be assured to a high probability. However the low cost unit should also be able to access the expensive system. See previous submissions for details.

See Mike Masleid for details why such requirements are necessary.

18) Ability to support handoff

This is inter network operation. See previous submissions where long discussions on this important area can be found.

19) Implication on complexity of the PHY

A preliminary hardware block diagram for this access method can also be found in previous submissions. This is very simple as all oscillators are locked and operate in a straight forward classical transceiver design with minimum signal processing overhead. A burst receiver on the other hand is a much more difficult task.

20) Ability to support broadcast

General broadcast is the basic building block of this method.

21)Preservation of time order Of SDU to the end systems

This is demand assigned system. The problem never existed.