MAC ISSUES FOR SUPPORTING A DUAL RATE PHY

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Abstract

This paper presents the advantages of supporting a dual rate PHY and addresses many of the issues that have been raised since the committee adopted the 1 MBit/s / 2 MBit/s PHY in March. The issues that are addressed were raised concerning the MAC's support of a dual rate PHY, many of which were extracted from mail threads on the Internet.

1. Advantages of a Mixed Rate Protocol

This paper will attempt to cover the advantages of supporting a mixed rate protocol at the MAC level. These include higher performance, greater coverage, expandability of the MAC to support future data rates, and a significantly lower infrastructure cost. This paper will also address some criticisms of the mixed rate protocol, mainly the added complexity, and will show that the impact on the MAC can be minimal.

LAN customers are constantly demanding higher performance levels. At 1MBit/sec, the 802.11 proposals are already a factor of 10 below standard Ethernet LANs in terms of raw data rate. Current commercially shipping Wireless LAN products already offer dual rate systems that gear shift up to speeds closer to Ethernet performance where possible, but operate at a base speed when necessary, due to environmental or range considerations.

Some have suggested operating only at the higher speed gear shift mode, but a serious drawback is the decrease in coverage area and the resulting increase in infrastructure cost in terms of the number of access points required in a large facility. As technology advances, and operating frequency bands change, a MAC which supports mixed rates will already have the features provided in it to allow new implementations that can work within the existing standard format.

2. Should the MAC be Aware of the Data Rate of the PHY?

Concerns have been raised that the MAC should not have to be aware of the data rate of the PHY. The concern is that this produces an entanglement between the MAC and PHY layers. Looking to the 802.3 specification as an example, the MAC protocol not only is aware of the 10 Mbit/s data rate, it is also aware of the propagation characteristics of the wire. These are both physical layer characteristics, but factor into the MAC state machines nonetheless.

In order for the MAC to calculate the NAV, it must know many of the performance characteristics of the PHY. The data rate, the TX to RX switching time, and the carrier sense delay all factor into this calculation. By making the MAC aware of the data rates, the door is open for future enhancements in data rates without revisiting the standard.

3. Control Packet Speed?

There has been some discussion as to whether the control packets should be transferred at the base mode, the gear shift mode, or both. There are a couple of significant advantages for transmitting all control packets at the base mode rate and some problems if they are not.

The most significant advantage to transferring all control packets at the base rate is that it allows inter-operability between STA's that are multi-rate capable and those that support only the base mode rate. This allows an

implementation based upon the base mode rate to comply with the protocol specification without the additional complexity of supporting gear shift mode rates.

The speed negotiation would take place in the RTS - CTS exchange. A station that desires to transfer data at the gear shift rate could set a bit in the MAC header requesting to transfer at the higher data rate. A node that is not capable of receiving at the gear shift rate would always respond by resetting the bit in the CTS frame informing the requester to transmit the data at the base rate.

The problem with transferring any control packets at a rate other than the base rate (particularly RTS or CTS) is that it eliminates the possibility of mixing multi-rate capable systems with single rate systems that operate at the base mode rate.

Another disadvantage of transferring control packets at the non-base rate is that the reception of data is less reliable, causing more stations to miss the RTS or CTS. These nodes would then be unsynchronized with the network, placing them in the situation of potentially interfering with another transmission.

4. Hidden Terminals with a Multi-Rate Protocol

The issue was raised as to whether or not a multi-rate protocol would have an impact upon hidden terminals. There is an obvious need to minimize or eliminate the affect that hidden terminals can have on the performance of the network.

One specific situation to consider occurs when a hidden terminal receives an RTS but does not receive the corresponding CTS. In this case, whether the RTS requested a base rate or gear shift rate, the hidden terminal will have to calculate the NAV based upon the lowest possible speed transmission. If the message is actually sent at a higher data rate, the hidden terminal would then be observing a NAV of longer duration than the actual transmission. The hidden terminal is at a disadvantage because the other stations that receive the CTS will adjust their NAVs to the shorter transmission time. Although the hidden terminal is at a disadvantage when contending for access to the network, it will not adversely interfere with other transmissions in progress.

An optimization could be made to allow the hidden terminal to update its NAV by having it listen and capture the data rate during the data portion of the transmission and recalculate its NAV if necessary. The implementation of this optimization would be entirely optional.

5. What Speed for Data Packets sent without RTS/CTS?

The DFWMAC allows some packets to be sent without an RTS/CTS exchange. Since the RTS/CTS negotiates the speed, an issue has been brought up as to what speed these data packets should be transmitted at. An easy approach is to always transmit these packets at the base rate to insure that the destination node has the ability to receive the packet. However, if the source station keeps a table of each node's rate capability, it may choose to send the packet at the gear shift rate whenever possible.

In the contention-free burst modes, the "DOWN" frames should be sent at the base rate since these contain the NAV to reserve time for the "UP" frame. Otherwise, stations unable to detect the "UP" frame may transmit over it.

In order to preserve inter-operability with nodes that support only the base rate, packets which must be received by all nodes must be transmitted at the base rate. This means that all broadcast and multicast packets must be sent at the base rate.

6. Data Rate, ANTSEL, TXPWRLVL Parameters

There have been discussions as to whether or not data rate, antenna, and TX power level selections should be passed as parameters to the MAC or if they should be strictly controlled through the management interface.

Since antenna and power level selections are based on the destination node, they should be passed as parameters along with the data to the MAC. An example of a call to the MAC is shown below.

ma.request (data, source, destination, data_rate, ANTSEL, TXPWRLVL, ...)

This allows these selections to be synchronous to the transmission of the packet as opposed to asynchronous if it were only controllable through the management interface.

If it is not made part of this interface, a separate management packet would need to be sent and processed prior to sending the data request packet. In addition to decreased efficiencies in doing this, it also places restrictions on how the management interface operates. Management functions within the MAC would need to have priority to ensure that they were performed prior to receiving the data packet.

These parameters should also be controlled through the management interface. One use of this capability would allow for monitoring traffic with various antenna configurations.

7. Resource Requirements for Mixed Rate Support

One of the most frequently raised issue is the increased resources required of the MAC for supporting a dual rate protocol, specifically memory storage for tables and processing power for table lookups. Tables may not be required at all in some cases, but if they are needed in a particular implementation, the following example shows how the MAC might be partitioned between the host and the Network Interface Controller (NIC) separated by a physical bus to optimize the use of resources.

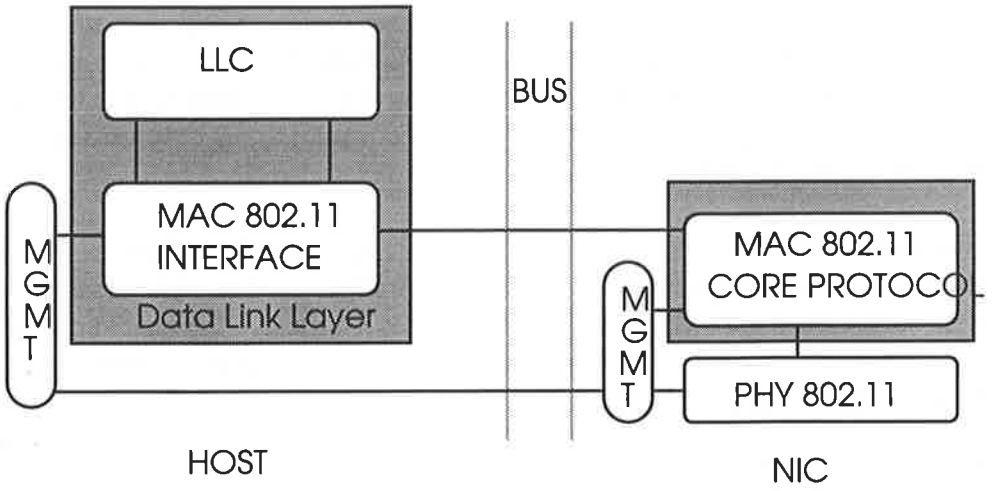

Figure 1

Figure 1 is shown here only as an example. It does not imply that this architecture must be followed. Separating the MAC into two pieces, one on each side of the bus, allows maximum flexibility in partitioning the work done by each piece. Since the resources of the NIC are generally more limited that of the host, it would be appropriate to locate the table on the host side of the bus. This places all of the decision making for antenna and data rate selection on the host side, simplifying the requirements of the NIC.

There is a question as to where the decision making process for antenna, speed, and TX power level selection should be. This functionality most naturally fits within the LLC portion of the Data Link Layer. Since the selection is based upon the destination address, it is similar to connection information which is not part of the MAC's definition.

The 802.2 LLC specification on the other hand has service definition for type 2 connection oriented service providing reliable point to point delivery of data. A type 3 service is also defined which is a connectionless acknowledged service providing reliable delivery of data without requiring a connection. Both of these services require the LLC to keep tables of sequence numbers for every address that it has transmitted to or has received from. This would suggest that the functionality belongs in the LLC.

7.1. Table lookups reduce throughput

A point has been made that the throughput of the node would not necessarily be improved in a mixed rate system because of the additional processing time required for looking up the rate at which the data should be transmitted. The overall impact that this has on throughput is very much implementation dependent. If the table lookup is done on the host side of the bus as discussed previously, the processing time could be reduced if the host processor is faster than that of the NIC.

Individual throughput is only impacted by table look up times in a non-busy network. In a busy network, the table lookup times are occurring concurrently while other transmissions are in progress, reducing any negative impact on throughput that the table lookup might otherwise have. In addition, it is likely that tables will be required by the host for purposes such as registration and power management anyways.

A dual rate system has benefits of increasing the aggregate throughput of the network. This in turn can increase the overall throughput of an individual station. Since the bandwidth available to wireless is already at a disadvantage to that of wired systems, increasing the aggregate throughput of the network is in the best interest of most wireless vendors.

7.2. Table maintenance

Since tables require maintenance in the way of deleting old entries (i.e., aging), this can also have an impact on the resource requirements to support the protocol. If this work is being done on the host side of the bus then the hardware costs are minimized.

8. Conclusion

The advantages of supporting a dual rate PHY have been presented along with many of the issues concerning the MAC's support of such a PHY. A case has been made to separate the functionality of the MAC between the NIC and the host system to provide the additional resources needed for table lookups. Also proposed was putting the table lookup functionality into the LLC, where it more naturally fits.

A case has also been made for requiring all control packets to be transmitted at the lower of the two rates, allowing transmitters that support only the lower data rate to inter-operate with each other.

In conclusion, the fear of gear switching that has been expressed is unjustified. Vendors will be permitted to develop products which operate at a base data rate, and the fact that gear shift options are available will have virtually no impact on them. The MAC is only being required to support multi-rate operation and not to include algorithms that will decide which rate to use. This can be accomplished without significant added complexity to the MAC, while providing an improved and expandable standard.