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Performance Simulation of Transmission Sensed Protocol

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Introduction

Recently there were a great deal of simulation results being presented on the transmission sensed protocol. This is basically a variation on the CSMA protocol with mutually controlled contact hand-shaking arrangement. The simulation results have an uncanny resemblance to the theoretical results published which have clearly expressed assumptions. These assumptions are limited to the characteristics of a benign channel environment. One question one might immediately ask is that if the known propagation characteristics, such as that measured in the GM Oshawa plant, and other very detail measured results showed the extreme hostile propagation profiles, are the simulations' results presented so far distorted the technical perception of the problems at hand? On the perusal of all the simulation results presented, the channel environment based is either totally benign, or a simple linear mean fading parameter is applied. This approach is acceptable for office, stationary terminal and a small node population environment, but it is far from acceptable under the propagation conditions in a real life portable environment. The intent of this contribution is to bring to bear the important parameters technical or otherwise that may have definitive influences in these analyses.

Market and Business View Point Parameter

As most of the interested parties in the wireless LAN industry have noted the slow process in which IEEE 802.11 is bringing out a clear indication of the standard's leaning towards a particular MAC or PHY structure. Undoubtedly, participants in the IEEE802.11 committee would also be similarly pressured by the same forces. It is interesting also to note that the majority of the current wireless LAN market direction is placing much emphasis on the replacement of cable. Thus it is easy to see the push to highlight the benign office cable LAN environment in the making of a MAC protocol for this use.

The CSMA based wireless LAN products have been available in the market for many years. Indeed, if wireless LAN is suitable for the replacement of cable, the history of IEEE802.3 would have replayed in IEEE802.11 a long time ago. The fortune of wireless LAN in this pursuit did not fare well, IEEE802.3 based wireless LAN remains a small niche market. Some enterprises failed as a result of failing to realize this important factor. The reason is clear, the office and stationary computing environments are more than adequately serviced by the cable LANs with very few exceptions. The effort to change this fact by a standard making process to legitimatize an inherent unsuitable solution will reach the same futile ends. If CSMA wireless LAN has not gained a notable acceptance, a MAC that betters the capacity by 2 to 3 times but shares the same CSMA MAC characteristics will unlikely to change the situation significantly. This is not a question of transmission capacity, cost or other technical contributory reasons, but a simple fact that wireless communication is not as conducive to carry high density information traffics as the cable can in the stationary computing environment, and the CSMA like MAC channel environment cannot fill the need of the general wireless applications which include terminal mobility.

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Wireless Station Population Parameter

Using the data submitted to IEEE802.11 [1], it clearly shows that 65% of the wireless LAN will have up to 30 stations, and the remaining 25% with more than 50 stations. This data indicates that to cover 90% of the possible wireless needs, a network shall require to service more than 50 stations per network. As a useful standard, any service coverage of less than 90% will not be acceptable. The same survey [1] indicates a network occupancy area of less than 5000 square feet.

Wireless Propagation Characteristics

A great deal of time and effort have been expended in the history of this committee to gather trustworthy propagation characteristics. The wireless propagation characteristic parameters are the fundamental differences that exist between cable and wireless media. Because of these differences, the usual cable environment analysis tools are mostly inadequate in providing a useful profile for the performance of the wireless medium.

The propagation characteristic parameters [2] shown below have been accepted by propagation measurement experts of the committee in the past,

Environment	**20 m atten.** $dB_{1\,m}$	**Slope dB/octave**	**Standard dev. dB**	**RMS delay Spread at -20dBc (nSec)**
Open Retail	29-35	10-13.8	2.1-5.3	10-150
Obstr. Retail	40	19.4	4.5	No data
Factory	25-32	5.7-7.3	4.8-10.2	30- 280
Office	39	11.7	2.2	10-50

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The measurement data were gleaned from measurements conducted at 915 Mhz ISM band. At 2.4 Ghz ISM band, it is expected that attenuation with respect to distance and frequency will be more detrimental, and the delay spread variance may be less (an intuitive guess).

This table provides a great deal of insight of the medium. One can expect the dynamic range required of the station is greater than 40 dB for a 5000 square feet coverage area. ISI will be a problem at chip rate longer than 15 nSec. Cross correlation performance has to be good for at least 250 nSec to reject self interference.

With such a large dynamic range, suitable high speed power control is necessary. The table below shows a back-of envelope estimate of what the propagation parameters mean to a MAC protocol.

Centralized Control MAC	**Distributed Control MAC**	**Reasons**
Code isolation is possible	Code isolation is not possible	No power control is possible in the case of a Distributed MAC and the signal dynamic range is large. Process gain < Dynamic range + Eb/No.
Frequency isolation is not critical	Frequency isolation is critical	If channellized frequency isolation is used, the roll-off of the channel filter has to be very good. This is because the power control is not present and the signal dynamic range is large.
No code correlation delay.	Code correlation delay has the worst case of N symbols where N is the number of chips per symbol.	Using a delay lock loop of skipping a chip per symbol, the worst case is N symbols delay for the distributed MAC. For the centralized MAC, the chip clock is locked beforehand.
Equalization training time can be slow	Equalization training time has to be at sub-chip rate	With minimum of 30 nSec delay spread, equalization is necessary to avoid ISI, if chip rate is less than 30 Mhz. In case of centralized MAC, the equalization is done beforehand.
No bit timing lock delay	Have to acquire bit lock.	In the case DQPSK, burst bit timing lock has to be locked. If bit-timing loop is made to be fast, bit jitters can cause bad BER. In centralized MAC, the PHY bit timing is locked beforehand.
Frequency stability of the station is not important	Frequency stability of the LO is very important.	In centralized MAC, PHY can acquire server frequency accuracy. In Distributed MAC, carrier frequency has to be very accurate.
General broadcast is possible and organized for ACK	General broadcast is very tedious and slow to receive ACK.	General broadcast can poll stations directly by assigning slots in the centralized MAC. In the distributed MAC, individual handshaking is necessary, and temporarily hidden terminals need to be recovered.
AGC loop delay is minimal	AGC loop delay is much longer	In a burst environment AGC loop delay has to be accounted for.

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From a brief review of the above table, it can be seen that systems with an uncoordinated burst type transmission pay a price in delay time. Using very optimistic rule of thumb, the burst type PHY will need at least 1.5 times the chip length in symbol time to acquire a burst, in a low cost product without the use of a high speed corelator. There are a number of other detail problems that no doubt the readers are familiar with.

Terminal Speed

There was also considerable effort expended in the defining the mobile speed of the terminal. Although the original estimate was 5-12 miles per hour, according to [3], 22.5 miles per hour is required. Effectively the coherence time is about 12.5 mSecs at 2.4 Ghz. This can be a significantly short time for a successful transmission.

2.4 Ghz Interference Potential

As the committee has decided to adopt a PHY at 2.4 Ghz, it is also important to investigate the interference potential at this frequency. The worst case scenario is that the available capacity is reduced by 50% due to the 50% duty cycle of the microwave ovens [4]. A simple assumption can be made that within 5000 square feet area, the microwave ovens would be using the same power polarity and therefore they are likely to be in phase. There is a problem when the collision based MAC is operated under this environment. The reason is that the interference is indeed indistinguishable from a signal collision. Without the ability to isolated the interference caused transmission outage versus a collision caused one, a degree of freedom in solving this problem is lost.

The effect of the inability to resolve the interference issue will impact the capacity to a great degree. In the case of carrier sensed MAC, a signal collision is resolved by time delay before the next transmission attempt in accordance with persistence settings. In the case of an interference caused signal outage, any time delay taken is a loss of transmission opportunity.

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Conclusions

This document is intended to highlight the importance of reviewing the simulation results reported so far in the context of actual propagation environment. As a recent article has pointed out, the success of wireless LAN is as an adjunct to the cable LAN market [5], and not as a replacement. Wireless LAN vendors should create new market where cable LANs fail to satisfy.

As a cable replacement, RF wireless LAN has failed, viewing from the market results of the products that are already in the market. A standard such as IEEE802.11 cannot turn around this trend, if it is designed emphasizing on cable replacement. It merely reflects the common prediction that "the beauty of standards is that there are so many of them." However, the possibilities for mobile and portable applications are omnipresent, the market potential is not clear because a truly workable RF wireless LAN in mobile, and hostile industrial environments do not exist.

To achieve this end, the IEEE802.11 MAC should prove that it can operate under a true worst case propagation environment. The approach to do this is for the PHY group to provide parameters listed above that are pertaining to a) Duplex Burst mode transmissions and b) Simplex continuous mode/burst mode transmissions.

References

[1] Doc: IEEE p802.11/91-47
[2] Doc: IEEE p802.4L/90-14
[3] Doc: IEEE p802.11/92-20
[4] Doc: IEEE p802.11/91-52
[5] Network World, June 22 1992, pp. 48