IEEE 802.11
Wireless Access Method and Physical Layer Specification

Title: **Recommendations For 2.4 GHz Frequency Hop Maximum Packet or Fragment Length**

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Abstract: It is recognized by many IEEE 802.11 committee members that RLAN systems compliant to their standard must operate in the face of microwave oven interference. This paper suggest that if the packet or fragment of the standard exceeds 400 Octets, then the first time packet success rate in the presence of microwave oven interference may be too low to insure proper total system operation. Therefore, a maximum fragment size of 400 Octets is recommended.

Introduction

Of significant concern to the PHY group is an appropriate maximum size for the data transmission packet, or fragment, of the Frequency Hop Spread Spectrum Physical Layer. This entity is called the Physical Layer Convergence Procedure Frame Format, PLCP, in Paragraph 3.3 of the March 1994 edition of the Frequency Hop Physical Layer Draft Specification, Doc: 94/068. While the RF channel may be free of interference in many scenarios it is clear from the previous discussions of the issue in Phy meetings of the past, that there is significant concern for the performance of the physical layer in the presence of RF radiation from microwave ovens. This submission address the issue of compatible operation with RF radiation from microwave ovens.

Overhead Assumption

In order to evaluate the performance of the communications system in the presence of microwave oven interference, the probability of interference as a function of packet length needs to be studied. This evaluation will show that interference becomes is less likely as the packets are made shorter. Each packet, however contains a certain amount of overhead data. Thus, as the packets are made shorter, the per cent overhead increases. To address overhead in this submission, a nominal allocation for overhead to account for Phy preamble, CRCs, addressing, etc., is made. This allocation is 40 bytes.

Microwave Oven Radiation

Radiation from microwave ovens has been studied and characterized by multiple investigators. A report from the NTIA is an excellent reference and is submitted as a document to the IEEE 802.11 committee in doc: 94/108. From this document it is apparent that the repetition frequency of the interference is 60 Hz, having a period of 16.67 mSec. Near the center frequency of the microwave oven radiation band the duty cycle of radiation is approximately 40 % as represented in Figure #1. Over a

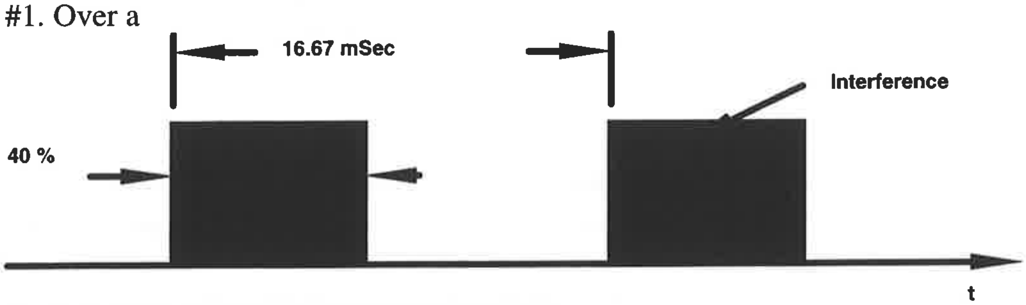


Figure #1 Center frequency microwave oven Interference

wider band, however, encompassing most of the ISM Band, the interference corresponds to the on/off and off/on transients of the microwave oven radiation cycle. This pattern is represented in Figure #2. In Figure #2, the width of the

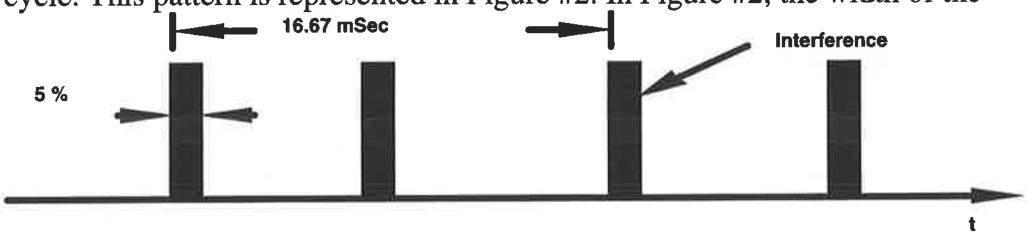


Figure #2 Interference pattern across most of the ISM Band

transient interference is represented as having a 5% duty cycle which is about 0.8 mSec. Because the pattern of Figure #2 applies more generally across the ISM Band, it is used as the model of microwave oven interference below.

First Attempt Efficiency

Microwave oven interference will cause some packets of data to have errors. This will in turn result in retry attempts. This submission focuses on the impact of the oven interference on the likelihood of success in the first attempt to transmit a packet and will consider a nominal allocation for overhead associated with each packet. The resulting figure of merit is termed, Expected First Time Throughput Data Rate, E_{FDA}, is defined as:

$$E_{FT} = P_{eff} * P_s * C_{DR}$$

where,

P_{eff} = Packet Efficiency = Payload bits/total bits per packet

P_s = Probability of first time success = probability that the packet does not overlap a microwave radiation pulse as illustrated in Figure #2, and

C_{DR} = Channel data rate = 1 Mb/s.

Based on the above discussion with 40 bytes of overhead in each packet, $P_{eff} = (P_l-40)/P_l$, where P_l is the packet length in bytes as shown in Figure #3. The

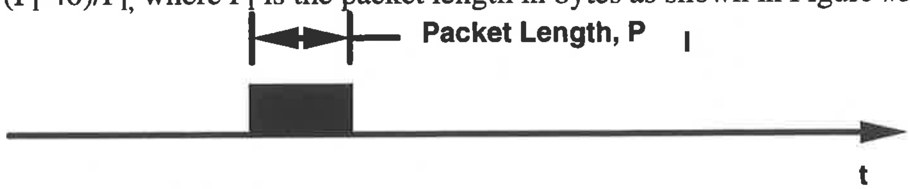


Figure #3 Data Packet Length

probability that the packet does not overlap with a microwave interference pulse, P_s is shown in Figure #4 as Probability of First time Success. Finally, the Expected First Time Throughput Data Rate, E_{FT}, is shown in Figure #5.

Figure #4 **Ps - Probability of First Time Success**

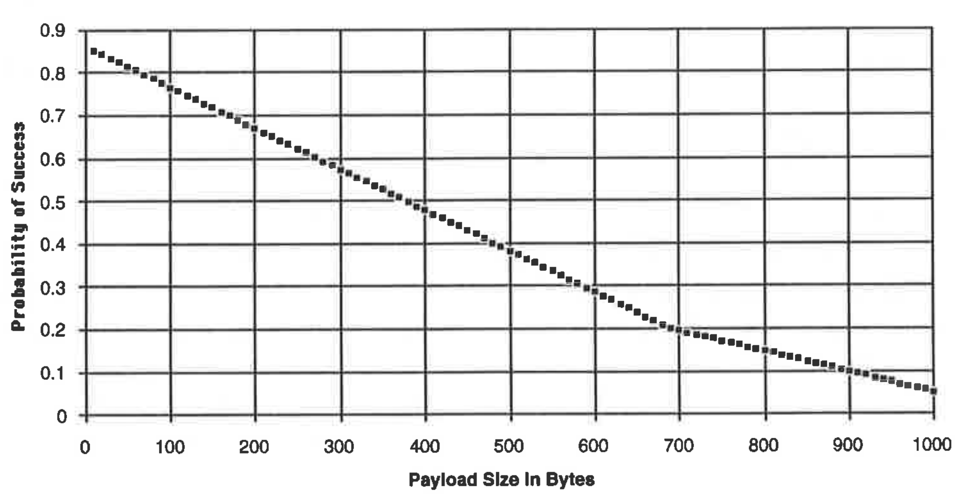
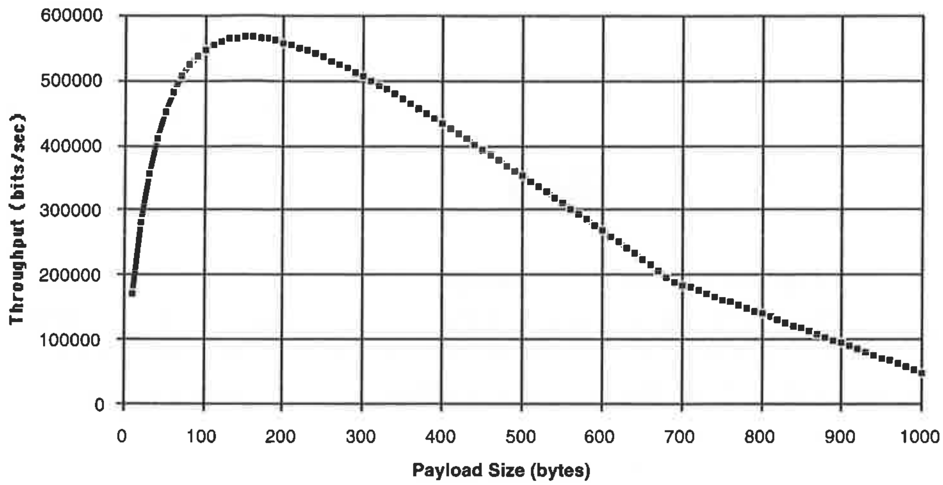


Figure #5 First Time Throughput Efficiency with Oven



Conclusions:

From the definition of P_{eff}, it is apparent that if the packet or fragment length is 400 Octets then the overhead efficiency will be 90%. Increasing the fragment length beyond 400 Octets yields decreasing returns in terms of overhead efficiency. From Figure #5 it is apparent that if the packet or fragment length is increase beyond 400 bytes, the Expected First Time Throughput Data Rate, E_{FDR}, decreases rapidly. Thus, there is an argument to suggest that 400 Octets be considered as the maximum length fragment or packet.

An even more compelling argument stems from consideration of Figure #4. In the presence of microwave oven interference, the first time success rate will be 50% if the fragment or packet length is 400 Octets. This may be high enough to be of serious concern to the Mac group. Consider, for example, a message of consisting of 16 packets. At 50% first time success rate, one packet would require 4 retransmissions to successfully transfer with 50 % confidence. While this may be a manageable challenge for the Mac group, consider the problems associate with a 25% first time success rate that would be achieved if the packet length where 600 Octets. One packet would require 12 retransmission to successfully transfer with the same confidence. This does not appear reasonable in light of backoff algorithms requirements and resulting delays. It is therefore concluded that the maximum packet or fragment length recommend by the Phy group to the Joint Mac-Phy group be 400 Octets.