IEEE 802.11
Wireless Access Method and Physical Layer Specifications

Title: Mixed Bandwidth Dynamic Listen Before Talk (DLBT) analyses

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Abstract: This paper gives an analyses of the medium sharing characteristics of Dynamic Listen Before Talk (DLBT) as it is currently under discussion within the Packet sub-group of Wintech. The objective of this industry group is to propose FCC rule making by specifying an Etiquette to allow co-existence between different dissimilar systems. An interference analyses is done based on the power limits as suggested, and a selected Defer Threshold. In particular the impact of un-channelized mixed bandwidth systems is addressed.

It is argued that DLBT approach does not work with mixed bandwidth overlapping systems.

Conclusion:

Interference analyses show that the probability for lost packets increase significantly when mixed bandwidth systems overlap. It is also shown that the lower speed system range is highly effected by the overlapping wide band system.

The large difference in DLBT response times of the different bandwidth systems will cause a large collision window that will increase the collision probability between mixed bandwidth systems. The access fairness will be very unpredictable and very hard to control. Multiple channel operation in parallel with unpredictable overlap, will cause that the wide band system is not able to transmit for several seconds, or may even be prevented from accessing the medium at all.

Therefore a fixed channelized allocation of the 10 MHz Data sub-band is proposed, that allows coexistense based on DLBT.

Introduction:

The objective of the WinForum/Wintech industry group is to propose FCC rule making for the spectral efficient use of the non-licensed PCS band allocation. The goal is to specify an Etiquette that controls transmit power, bandwidth, band allocation and transmission time so as to provide fair access and coexistence for different classes of short range systems targeted for this band. FCC NPRM Docket No. 92-100 recognizes 3 bands within the proposed 20 MHz allocation for non-licensed use. The 2 channelized sub-bands of 5 MHz each are considered for use in connection oriented, time bounded services and the 10 MHz non-channelized band is for use in "bursty" packet oriented data systems. WINTech is initially investigating a sharing etiquette appropriate for each type of use and two sub-groups have been established. These are the circuit switching sub-group and the packet switching sub-group. The eventual objective is to define an etiquette which will allow each type of use without segmenting the band.

Initially, the packet switching (date) group is considering operation in the 10 MHz wide non-channelized sub-band. Coexistence between dissimilar systems is intended to be controlled by a DLBT procedure, together with limits on transmit power and occupancy time each of which are functions of the bandwidth.

At the time of this writing there is no consensus, but a "Etiquette Strawman" draft is under discussion.

Data Sub-band Etiquette summary

The objective is to specify a simple set of rules to control Power limits, Frequency limits and Time limits, which are as follows:

* Power Limits
    - Power spectral density of p=5*10(^-7) W/Hz
    - Max transmitted power P= 250 mW, or 1W when adaptive Power Control is applied.
    - A spectral efficiency rule that limits the transmit power P to P= user data rate/bandwidth/2, that promotes 2 bits/Hz systems.
    - When antenna gain is more then 3 dBi, then max power must be limited to compensate for the higher transmit gain.

* Frequency limits
    - Bandwidth between .1 MHz and 10 MHz
    - Digital modulation
    - Bandwidth is defined as 99% of transmitted power

* Time limits
  - Max occupancy time per access t=2*10(^4)/B * Pmax/P
  - Duty cycle
    . Non-DLBT then duty cycle is limited to 50% in any 4t, 12.5% in any 20t and 1% in any 1000t period.
    . 80% duty cycle when DLBT is used.

Furthermore the DLBT function is to be specified by the threshold to be applied, the detection time limit, and a backoff procedure.
Both the threshold and detection time will be specified as function of the bandwidth. As an incentive to limit the power as much as possible, the threshold can be increased by the same amount of dB's as the unit is operating below the nearest power limit.

Interference analyses approach

Figure 1 is a graphic representation of the Power spectral density (Psd) as function of the bandwidth used. The objective is to analyze the interference situation between the different bandwidth systems. In general the assumption is that a customer does install only one kind of wireless LAN system that allows interoperability. This means that dissimilar wireless LANs that fully overlap operating side-by-side in the same customer location will be highly unlikely. Overlap may occur between neighboring systems in densely populated area's. This can for instance be different stores in a Mall on the same floor, or on different floors, or similar situations in office buildings.

The following 2 overlap situations will be further analyzed:

- a 10 MHz system partly overlapping a 1 MHz system
- a 10 MHz system partly overlapping a 100 KHz system

For simplicity reasons the following system specifications are used, which do not fully comply with the proposed draft rules:

- All systems use 1 bit/Hz modulation (has effect on thresholds used)
- The spectral efficiency power limit rule is not applied (max Psd according to fig 1)
  Note that this will result in an absolute difference, but relative between systems it won't have effect.
- The power limits then translate as follows for the non Power control case:

10 MHz:	Pmax=250 mW = 24 dBm	Lvl(1m)=-14.1 dBm
1 MHz:	Pmax=250 mW = 24 dBm	Lvl(1m)=-14.1 dBm
.1 MHz:	Pmax= 50 mW = 17 dBm	Lvl(1m)=-21.1 dBm

  Note that for simplicity reasons it is assumed that the .1 and 1 MHz are channelized similar to the 10 MHz system. The 10 MHz spectrum shape should be such that it meets the outoff band criteria, and will therefore need some spectral roll-off to achieve that. A similar roll-off is assumed for the .1 and 1 MHz systems, so that the ratio between the 6 dB bandwidths of the different systems are nice round numbers of 10 and 100.
- As detector threshold the following assumptions are made

1.9 GHz man made noise + Rx noise:	approx.	13 dB
Fade margin for 10(^-2) outage:	assume	10 dB
Demodulator margin @ 1bit/Hz:	approx.	14 dB
		================
Total margin above thermal noise:		37 dB

Note that the Fading margin to be applied will depend on the bandwidth used and the delay spread we can expect in a given environment. For narrow band systems this margin will probably need to increase.

The defer threshold is for this example choosen as follows:

1.9 GHz man made noise + Rx noise:	approx.	13 dB
Carrier detect margin	assume	11 dB
		==================
Total DLBT threshold above thermal noise:		24 dB

Note that no fading margin is included, and a rather large carrier detect margin is used to allow fast detection. The actual margins to be used will be a trade-off between coverage area, defer area or sharing factor. Note that a different modulation scheme will translate in

to allow fast detection. The actual margins to be used will be a trade-off between coverage area, defer area or sharing factor. Note that a different modulation scheme will translate in a different detector margin, and consequently a different range and sharing factor.
Further analyses will be needed to determine this threshold.

The resulting interference relations are shown in 3 plots in figure 2. For each of the 3 bandwidths a plot is made of the average probability of the signal level as function of the distance. As environment, a typical semi-open office environment is chosen with the following characteristics:

- Free space attenuation (n=2) for the first 10 meters.
- Beyond 10 meter an attenuation factor of 3.5 is used.
  This translates into roughly 10 dB attenuation per distance doubling.
- A homogeneous environment is assumed with identical attenuation factor in all directions, and not further increased with distance. In reality we will more likely run into a big separation wall when the distance becomes larger, so that the attenuation will in that case tend to increase.

The above assumed thresholds and bandwidths result in the following:
Based on a detector threshold of 24 dB above thermal noise is -174 + 24 = -150 dBm/Hz, that translates into an absolute threshold as function of the bandwidth of the different systems by multiplying it with the bandwidth resulting in:

- Defer threshold for 10 MHz system is - 80 dBm
- Defer threshold for 1 MHz system is - 90 dBm
- Defer threshold for .1 MHz system is -100 dBm

The DLBT detection function assumes that all energy is measured within their receiver bandwidths, which is supposed to be identical (matched) to the transmitter bandwidth used.
Note that for simplicity reasons the full channel bandwidth (used + guard band) is assumed to calculate the threshold, rather than the actual roll-off bandwidth.
Also in the further interference analyses only the fully inband case is assumed, so a 1 MHz system overlapping a roll-off part of the 10 MHz spectrum is not assumed here.

Figure-2 shows the average attenuation curve as function of distance, with an x MHz system active in the origin. It also shows two solid lines, which represent the "Defer threshold", and the "Detector Threshold" of the given system.
Furthermore Attenuation curves are shown of potential interferers, which can be in the air, because their total energy as seen by the x MHz system is just below the "Defer threshold". Please note that the peaks of the interferer curves are not accurate, due to lack of resolution, and nearby formula accuracy, but this has no effect on the accuracy of the rest of the curves.

Interference analyses

10 MHz system:

- All the power send by a 1 MHz system will be seen by the 10 MHz system. Because the maximum power of the 10 MHz system is the same as that of the 1 MHz system, they will have identical defer boundaries, as shown in the plot (approx. 204 meter).
- All the power send by a 100 KHz system will likewise be seen by the 10 MHz system. Since the maximum power of the 100 KHz system will be 7 dB lower, that results in a shorter defer distance (approx 130 meter).
- When more 1 MHz systems would be active which each use a different band, then that will result in a larger defer distance, because the total energy at the detector will increase. However while a 10 MHz packet is being send, more 1 MHz interferers can become active beyond the 204 meter defer boundary, that may then increase the interference level to above the SIR boundary at that location. This will then result in jamming errors. This will of course be similar for multiple 100 KHz overlap.

Note that the effect is that the noise limited range is approx 85 meters. However due to the possible interference, the range will be around 50 meters as indicated by the SIR arrows, which is the required detector margin for a sufficient low BER.

1 MHz system:

- The normal "Defer" threshold for a similar 1 MHz system operating in the same band will be close to 400 meters.
- The 1 MHz system will see only 1/10 th of the total power that is transmitted by the 10 MHz system, (so its peak is 10 dB down) and this will result in a defer distance of approx 204 meter. Note that although the system sees only 1/10 th of the 10 MHz energy, it will still have the same defer distance because the threshold of the 1 MHz system is 10 dB more sensitive.

- A 100 KHz overlap situation is not shown, but will show a similar curve as in the 10 MHz system, at the same location, but 10 dB higher in level.

The noise limited range of approx 170 meter would reduce to approx 110 meter when other 1 MHz systems using the same band are in the area, and it will be reduced further to approx 85 meters when a 10 MHz system is partly overlapping.

100 KHz system:

- An other 100 KHz system using the same band would have a defer distance of approx 485 meters. Note that this situation is less likely when we assume that a proper frequency management method is in place to use the available channels such that a maximum of isolation between neighboring systems is achieved.
- The 1 MHz system will be seen 10 dB down by the 100 KHz system, but because of the 10 dB more sensitive receiver will have a similar defer range as the 1 to 1 MHz system (close to 400 meter).
- The 100 KHz system sees only 1/100 th of the energy of the 10 MHz system (so its peak is 20 dB down), and this results in again a defer distance of approx 204 meter, because the 100 KHz receiver is 100 times (20 dB) more senitive.

The noise limited range of approx 204 meter would decrease to approx 130 meter due to a partly overlapping 1 MHz system and down to approx 90 meter when a 10 MHz system is partly overlapping.

When comparing the effect of mutual interference in the 3 systems, it is clearly shown that the systems coverage area will be interference limited rather than noise limited. This will be especially true for the single 10 MHz channel, because it is a single channel.
One way to use the different number of channels available when using lower speeds is for isolation between cells that use the same frequency. This will increase the average distance to potential interference significantly, so that operating ranges closer to the detector threshold will be possible (less interference limited).

An effect that is not immediately visible is that the behavior of the systems is not symmetrical. This is the case when there are non linear power density relations like between the 10 MHz system and the 100 KHz system.

- When a 100 KHz interferer is active beyond the 130 meter defer boundary of the 10 MHz system, then the 10 MHz system will start transmitting anyway. This means that in the

100 KHz plot, there is an other curve of a 20 dB down 10 MHz system interfering at 130 meter or beyond. This will further reduce the coverage distance to approx 50 meter, so identical to the 10 MHz practical coverage distance.

- A 100 KHz will not start transmission until it does not see any other 10 MHz system active within 204 meter. However when a 100 KHz transmitter is active, then a 10 MHz system between 130 and 204 meter away will start transmission anyway.

This asymmetric behavior causes jamming of the on going 100 KHz traffic by a 10 MHz system. This is especially problematic when we consider that the 100 KHz system will have 100 times longer packet, so that the probability of a hit can be very high.
This does not exist between one 1 MHz and the 10 MHz system, because the power spectral density ratio is inverse to the bandwidth ratio.
However when multiple 1 Mhz channels will be active beyond the 204 meter defer distance, then a similar asymmetric behavior will cause an increasing number of lost packets in the 10 MHz system.
This similar effect as described for a 10 MHz system overlapping a 100 KHz system will show up between the 1 and 10 MHz system utilizing the 1 Watt power level, so when the symmetric power spectral density relation is changed by allowing 1 Watt maximum power when using power control.

Interference conclusions:

Overlap between systems with different Bandwidths will cause significantly reduced operating ranges for the 100 KHz system, or result in a high probability of errors due to jamming. Similar when more further away .1 or 1 MHz systems are becoming active during the time while a 10 MHz system is transmitting, then the probability for jamming errors may increase as well. This unreliability is mainly due to the mixed bandwidth effects.
Summary:

- 10 MHz will be jammed when more then one .1 or 1 MHz channels are turned on (during the packet).
- Range of lower speed systems will be severely decreased by the 10 MHz system, especially for the 100 KHz system.
- 10 Mhz system will jam over 100 KHz packets in part of the area.

DLBT Detection time consequences

As shown above, the sensitivity of the receiver and the DLBT threshold used is a function of the bandwidth, which in a noise limited environment will increase the coverage area.
In a DLBT system, the energy detection time is an important parameter, because it determines the access fairness and the collision probability between the dissimilar systems.

The energy detection speed of different systems will be inversely proportional to their bandwidths. A practical achievable relation is considered to be: DLBT response time = 20/B.
This translates into:

	Speed	DLBT response time	10 MHz equiv. bit times
-	10 MHz system:	2 usec	2-3 Bytes
-	1 MHz system:	20 usec	16-32 Bytes
-	.1 MHz system:	200 usec	160-320 Bytes

Note that the 2 usec response time is highly effected by the medium propagation delay, such that the achievable medium DLBT response time would be 1-2 usec larger.

The difference in detection times will present major problems.

The lower speed systems will take a very long time relative to the high speed system, to detect that the medium is free again after a defer. The effective access priority difference will have the same ratio as the bandwidth ratio. At the same time this means that the slower speed system is too slow to detect in time that a higher speed system has already captured the medium. This results in a very large collision window relative to the high speed system. Depending on the spectral efficiency (1 bit/Hz or 2 bit/Hz), and the strength of the signal above the defer threshold, the high speed system may have already send a large number of Bytes when the slower speed system accesses the medium because it did not see the high speed yet. So the probability of collisions will be very large. This is also the case when a backoff algorithm is being used to lower the probability of a collision after a defer.
This can be partly prevented by slowing down the detection function of the high speed system to more or less match the slowest speed system. This will however be very inefficient for the high speed system.
This does however not decrease the collision window, but can only control access priority better, by matching contention resolution windows of the different systems.

Consider the following scenario:

When we consider the 100 KHz system with its large DLBT response time, listening to the medium on which the 10 MHz system generates a lot of short packages, then depending on the duty cycle of these short packets, this traffic would never be seen by the 100 KHz system. This system will then in turn access the medium, thereby jamming the medium, with a long packet, causing lost packets. Once the 100 KHz system would have its transmitter on, likely causing a collision with the high speed system, then this will prevent the 10 MHz system of accessing the medium for a relative long time (up to 200 msec for a maximum 100 KHz packet size under max power conditions).
In the mean time other 100 KHz or 1 MHz systems operating in different bands will be allowed time to access the medium as well. Due to the fact that the different slower speed systems using non-overlapping bands do not have to defer to the other active channels, it is possible that the 10 MHz system does not see a silence period that allows it to access the medium, for several seconds.
An 800 pound gorilla system could be imagined that uses two separate low speed channels to operate full duplex. A system like that may easily generate synchronized traffic patterns on both channels such that the medium is never free for a high speed system.
Of course the same applies to the mix of a 10 MHz and 1 MHz system.

Mixed bandwidth access fairness discussion:

What is fairness in a mixed bandwidth environment?
One possible approach is when a slow and a fast system would have equal air time, so that the fast system can have a throughput that is proportional higher then the ratio between their bitrates.

1: So a 1 MHz system mixed with a 10 MHz system should result in a factor 10 throughput difference also when they are mixed, resulting in a overall throughput reduction to 55 % compared to a non-overlapping case.
2: When 10* 1 MHz systems use all separate channels but overlap with one 10 MHz system, then the 10 MHz system should still have a factor 10 throughput ratio compared to the individual 1 MHz systems, and its throughput should drop to approx. 50 % of its non-overlapping performance, while the total throughput for both kind of systems would still be 100 %.

It should be recognized that the throughput ratio can not be obtained by allowing longer packet lengths, because the packet length distribution is a function of the higher layer protocol, and will be limited in max packet size.
Rule 1 translates into a requirement for an access priority difference equal to the bandwidth ratio of the systems, while rule 2 would require that this priority is changed as function of the number of 1 MHz systems contending for access with the 10 MHz system.

The DLBT response time difference suggests that this priority difference is automatically achieved, except for the required change in access priority as function of the number of channels contending for the medium.
However the speed difference does also translate into a large increase in collision probability, because the collision window increases significantly. Other side effects are that the performance is unpredictable for both type of systems, because it suggests that either of the two different systems can claim the network for a very long time, before the other systems gets access again.

Response time effect summary:

- Large difference in access priority needed to achieve perceived access fairness.
- Large detection time differences translate into a significant increase of the collision window, and so the probability of lost packets for especially the high speed system.
- It is possible especially with 100 KHz systems overlapping with 10 MHz systems that the 100 KHz systems does not see the short packets (majority) of the 10 MHz system.
- This in turn causes the low speed system to jam the medium, which then can be occupied very long due to longer packet times and parallel activity on multiple 1 MHz channels.
- Unpredictable performance.
- An 800 pound gorilla would be a full duplex system that utilizes two or more lower speed channels. This can wipe out the 10 MHz system completely.

DLBT Conclusion:

- DLBT does not work to control coexistence between unchannelized mixed bandwidth systems.
- The asymmetry caused by mixed bandwidth interference results in a much shorter coverage area for the low speed system.
- The performance of both the high and low speed system will be seriously effected.
- The coverage area and the performance of the low speed system will be decreased considerably.
- 800 pound gorilla's will predominate.

This justifies the conclusion that we need to prevent mixed bandwidth systems overlapping in the same spectrum, because co-existence and fair access of the medium can not be achieved otherwise.
Using mixed bandwidth systems, creates a lot of uncertainty, that will seriously limit the ability to make a good interoperability standard.

WINTECH CHANNELIZATION PROPOSAL

Wintech goals:
There are 3 levels of control of the 1.9 GHz unlicensed band.

0-	Interference control by powerlimits:	Regulatory/Etiquette
1-	Co-existence:	Regulatory/Etiquette
2-	Interoperability:	Standard (such as 802.11)

In our opinion the goal of Wintech / Winforum should be to develop an etiquette that allows co-existence between the various systems that will evolve in the unlicensed 1.9 GHz band. Three classes of users are currently recognized in the NPRM. These are:

- Connection oriented Cordless phone (Example:single phone systems)
- Connection oriented Periodic/Isochronous (Example: TDMA based multiple phone system)
- Wireless Data LAN systems (Bursty)

The etiquette should coordinate coexistence within each of the 3 classes as well as between the classes.The intention is to develop an etiquette that will be a blue-print for the rules that the FCC will apply.

Our feeling on the matters which have arisen are summarized below.

1. Winforum / Wintech should develop the full etiquette referenced above.
2. Separate bands will be needed for the identified classes.
3. DLBT should be the basis for the Etiquette within the wide band packet channel. (We don't want anarchy)
4. The wideband portion should be channelized to permit efficient use of LBT on a packet basis. We prefer 8 * 1.25 MHz channels.
5. The four 1.25 MHz isochronous type channels should be located adjacent to the wideband class.

2: Separate bands needed for Voice and Data

When we look at the application and characteristics of the different classes of users that have currently been identified, then the following can be concluded.:

- Wireless PBX type of applications and Wireless data LAN type of applications should be able to operate in the same area, so they should be able to fully co-exist with each other side by side and overlapping.
- It is unlikely that multiple dissimilar LAN's will be used side-by-side within one

customer location. So there normally will be a certain level of spatial separation between dissimilar wireless LAN's. A next door neighbor may have a different LAN that should be able to utilize the same band. This means that dissimilar LAN systems may partly overlap, and they need to be able to co-exist in the same band.

- The characteristics of real time Voice systems or connection oriented isochronous systems and "Bursty" data LAN systems are significantly different from each other.
- LAN traffic is very "Bursty" in nature and requires relatively wide bandwidths to achieve acceptable response times. Its characteristics are such that they, within certain restrictions, can perfectly co-exist on the basis of a Dynamic Listen Before Talk (DLBT = LBT on a packet basis) protocol.
- On the other hand the characteristics of the Voice systems are such that they can not tolerate to share the same medium with other systems based on a DLBT protocol. A "Listen Before Use" (LBU) method can be applied on initial access to determine that it is not in use by an other periodic system.
- A degree of overlap may be possible on a LBU basis.

This results in the conclusion that there should be separate primary spectrum allocations for these classes.

3: Etiquette to be based on DLBT needed to manage access in 10 MHz packetized band.

DLBT Dynamic Listen Before Talk definition

- In this type of LBT a transmitter will sense the energy present in the band, before it will access the medium.
  If energy above a given threshold is detected, then the transmitter will defer transmission until the medium is available. Then the transmitter can access the medium following a pre-determined procedure that can (and should for the packatized data class) involve a random backoff to allow contention resolution between multiple systems, or between multiple components of a system.
- This is the type of LBT that can be used, <u>with certain restrictions</u>, to control coexistence in the 10 MHz packetized data band.
- The packet length per access should be limited. Note that packet length cannot be used to control fair access however. Packet length distribution will be a function of the higher level protocols.
- A quick response should be allowed after reception, so that an Ack packet can be returned without requiring the DLBT procedure.

DLBT Etiquette pros and cons:

A+ LBT allows multiple dissimilar systems with similar overlapping bandwidths (fixed channelized), to share the same band.
A+ Fair access can be obtained, resulting in throughput ratio equal to the average packet length ratio times the spectral efficiency ratio (of Bits/Hz).
A+ These characteristics provide for a well characterized medium availability on which an interoperability standard can be built.

A- DLBT does not work properly when dissimilar systems with significant different bandwidth ratios are overlapping in spectrum, and when the band overlap is unpredictable
A- A DLBT based etiquette does not allow for real time voice integration or isochronous services in the interoperability standard.

4: The 10 MHz Data sub-band should be channelized

The reasons for channelization are:

- Fixed channel width needed to allow DLBT to work.
- Interference levels are predictable.
- Larger coverage distance (2*) possible then with a single channel wide band system.
- Total system capacity/throughput of multiple parallel channels is the same as that of a single channel system.
- Response time performance of a single channel system (single 10 MHz channel) will be jeopardized and unpredictable because of neighboring Wireless LAN density growth. The major reason for high speed would be the requirement for a fast response time. As neighboring LAN deployment density increases, the response time deteriorates and eventually will be no better than a low speed LAN.
- Viable 10 MHz services need multiple channels, for which no spectrum is available in the 1.9 GHz region.
- Cost of a single 10 MHz system will be high due to delay spread limitations.
- Harmonizing the bandwidth to the same 1.25 MHz or the like, as used in the isochronous band, would allow us to use them when not in use by an isochronous system.
- 8 * 1.25 MHz permits a sufficient number of channels to effectively provide predictable performance in a dense deployment environment.
- 1.25 MHz implementation is already economically feasible.

5: Isochronous channel band should be located adjacent to the data sub-band.

This packet band then would be adjacent to a band with compatible channelization. An etiquette using dynamic allocation based on Listen Before Use (LBU) could permit and control overlapping use between the different classes. This would potentially allow the full 20 MHz spectrum to be used for data when there are no primary users operational in the "isochronous" type bands.
This concept of primary allocation for different classes of systems, and a secondary use status for the other systems, when not in use by primary users, would allow for flexible boundaries between the allocation for the different classes. This will yield a high re-use of the limited available spectrum resource.

Proposed Power Spectral Density

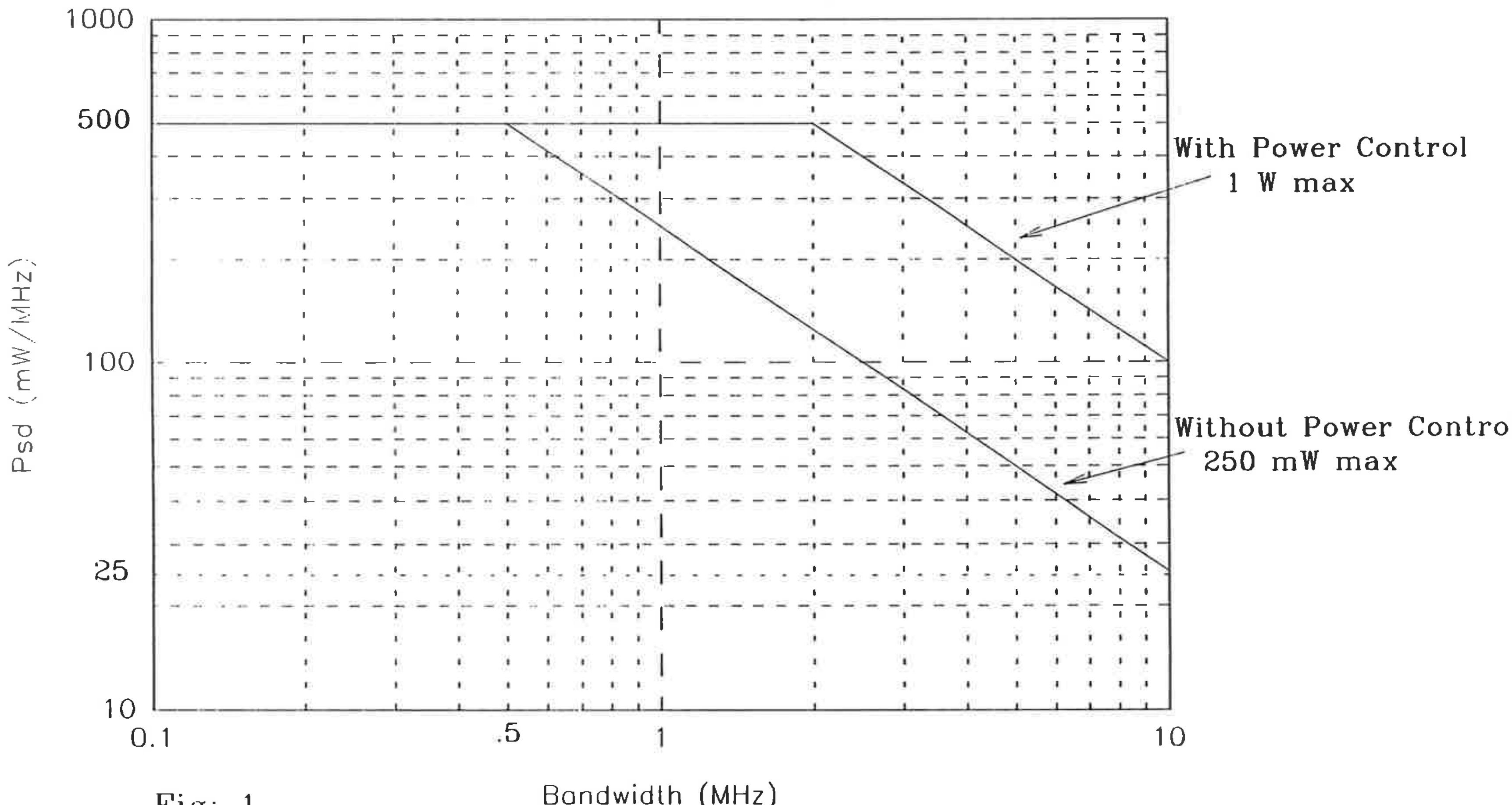


Fig: 1

MIXED BANDWIDTH INTERFERENCE SITUATION

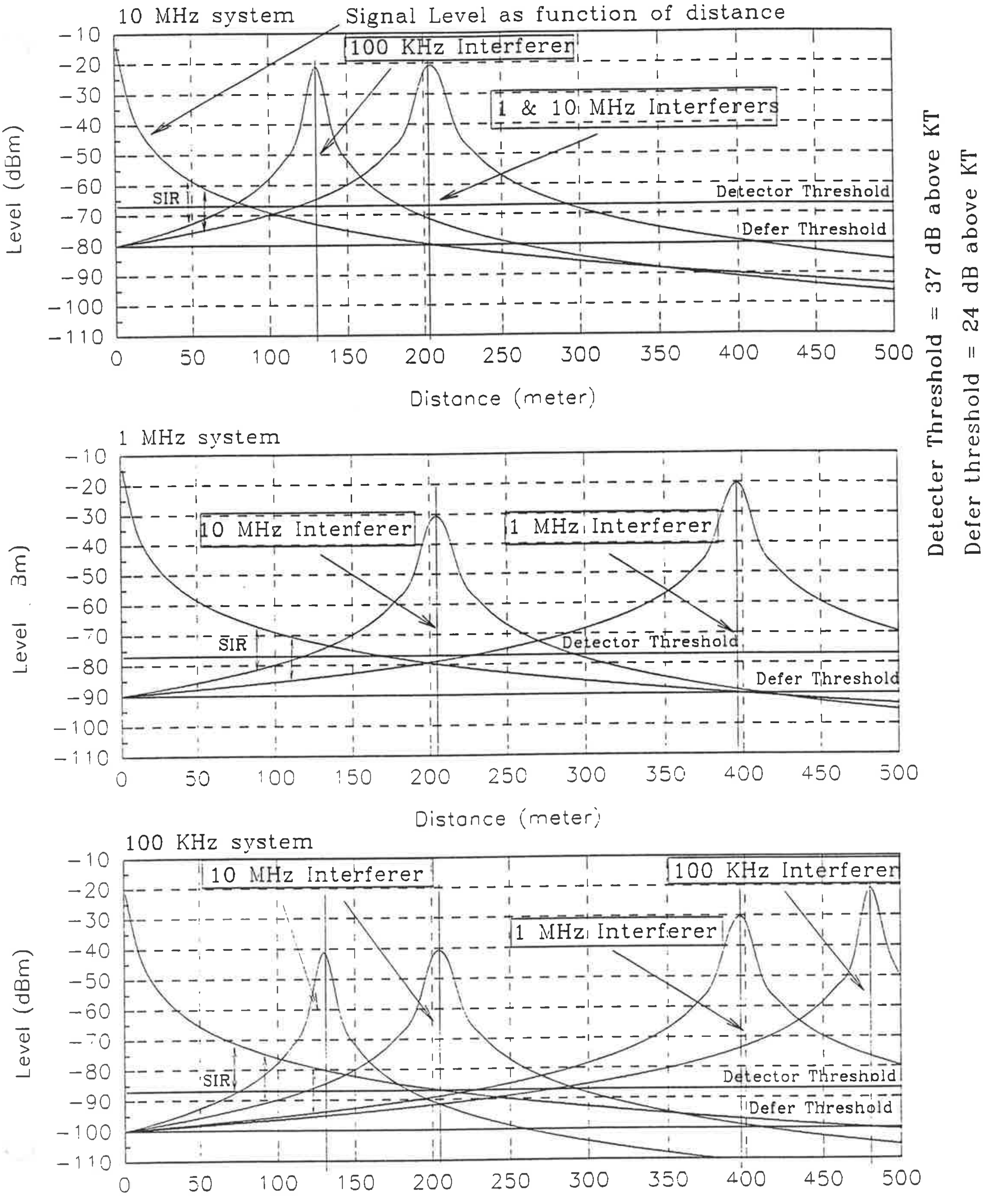
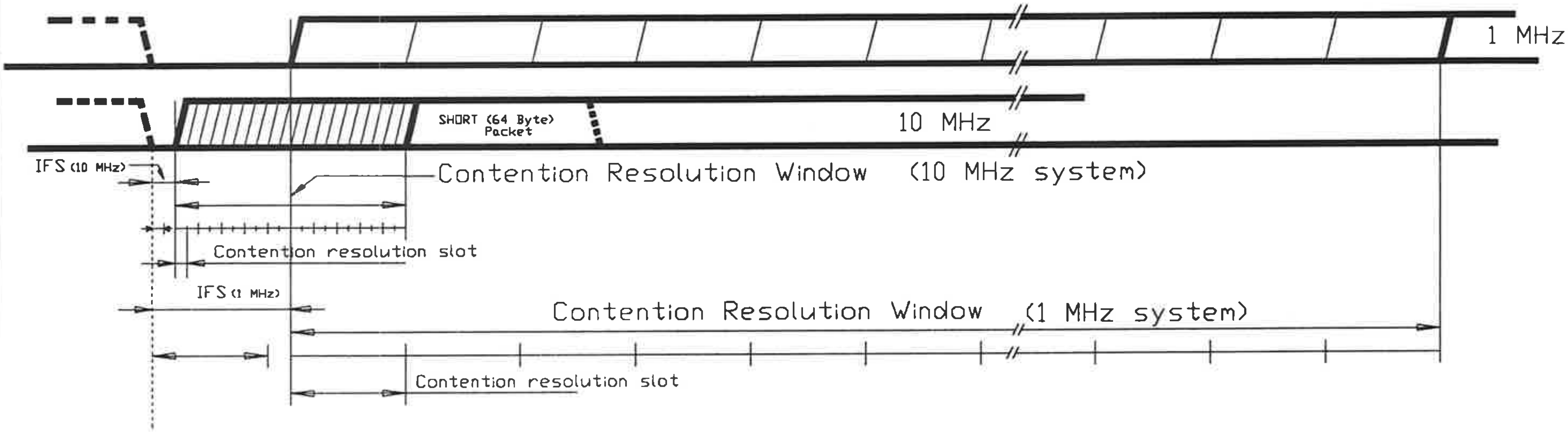


Fig: 2



Contention Resolution slot = Medium propagation delay + DLBT Detect response time

IFS = Inter Frame Space = DLBT response time + Tx/Rx turnaround time

Example: 20 contention resolution slots
Random slot selection after Defer
This results in 5% Collision Probability
Priority difference would be factor 10
However when 1 MHz system selects first slot,
- Then the Collision probability with the 10 MHz system will be 100 %
The 10 MHz short packets are a lot shorter then the 1 Mhz
- Contention window.

Fig: 3 DLBT Contention resolution example