THE WINFORUM SRDC AND THE U-NII BAND

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Lucent Technologies

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OUTLINE

Objectives and Scope of the WINForum SRDC

U-NII Band Description

Brief History of the U-NII Band

SRDC Positions on Sharing Rules and Standards

State of the U-NII Band Regulations

Need for Sharing Rules

Recommendations

WINFORUM AND THE SRDC

WINFORUM

- **Principal Industry Advocate of Unlicensed Frequency Use**
- **Industry Technical and Regulatory Expertise**
- **Wiley, Rein and Fielding Advisory Firm**

SRDC

WINForum Technical Committee for the U-NII band

OBJECTIVES AND SCOPE OF THE SRDC

Obtain U-NII Spectrum

Interact with Regulatory Bodies to Set Rules for Use of the Band

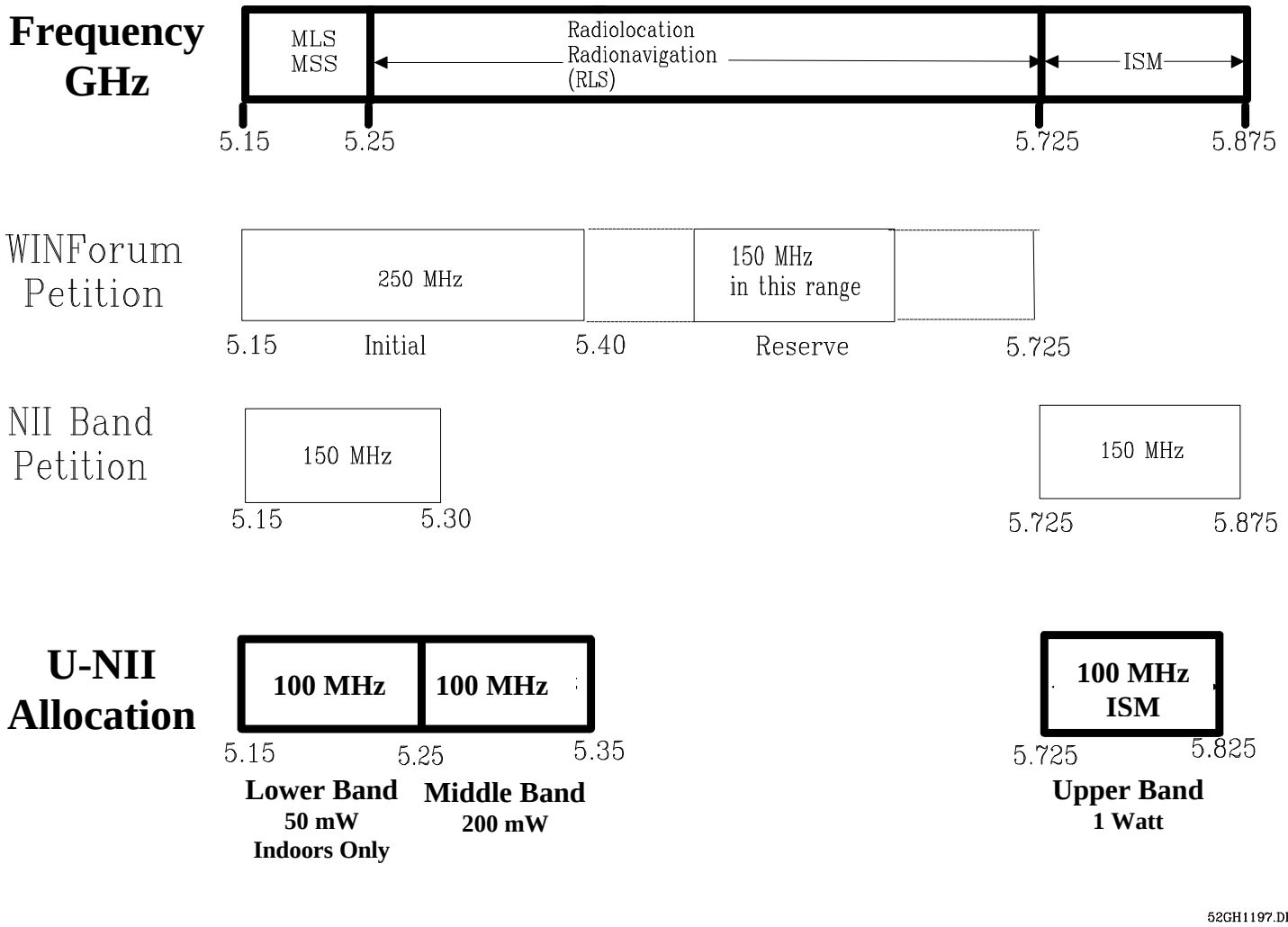
Develop Spectrum Sharing Rules for the Industry

- **Minimum Regulatory Framework**
- **Assure Efficient Use of the Spectrum by all Systems**
- **Constraints on Power, Bandwidth Transmission Time and Channel Access**
- **Minimal Rules to Permit Innovation**
- **Verifiable by Testing**

Promote Interoperability

Through Standards Bodies - Currently IEEE 802.11 and ETSI-BRAN

U-NII BAND FREQUENCIES



HISTORY OF THE U-NII DOCKET

WINForum Spectrum Committee Formed May 1994

Discussions with NTIA (Government Users) and FCC OET

August 1994 - May 1995

WINForum Petition Filed May 1995 - Apple Filed a Similar Petition

NPRM - April 1996

SRDC Formed July, 1996

Report and Order Issued - January 1997

Sharing Rules Minimal in Order

SATELLITE INTERFERENCE ISSUES

5150 - 5250 (Lower Band) Assigned to MSS Gateway Feeder Uplinks at WRC '95

Satellite Industry Opposed Allocation of the Lower Band to U-NII

SRDC Performed Detailed Analysis on Effect of Power Level and Antenna Gain on MSS Interference
- **Showed Effects on MSS System Negligible at 1 Watt and Any Antenna Gain**

SRDC Negotiated with Satellite Interests at Behest of FCC OET

Compromise
- **50 mW in Lower Band**
- **Maximum of 6 dBi Antenna Gain**
- **Inside Only Operation**

HIPERLAN Issue Still Undecided

From Reference 4 (Effect of (U-NII) on (MSS) Feeder Links)

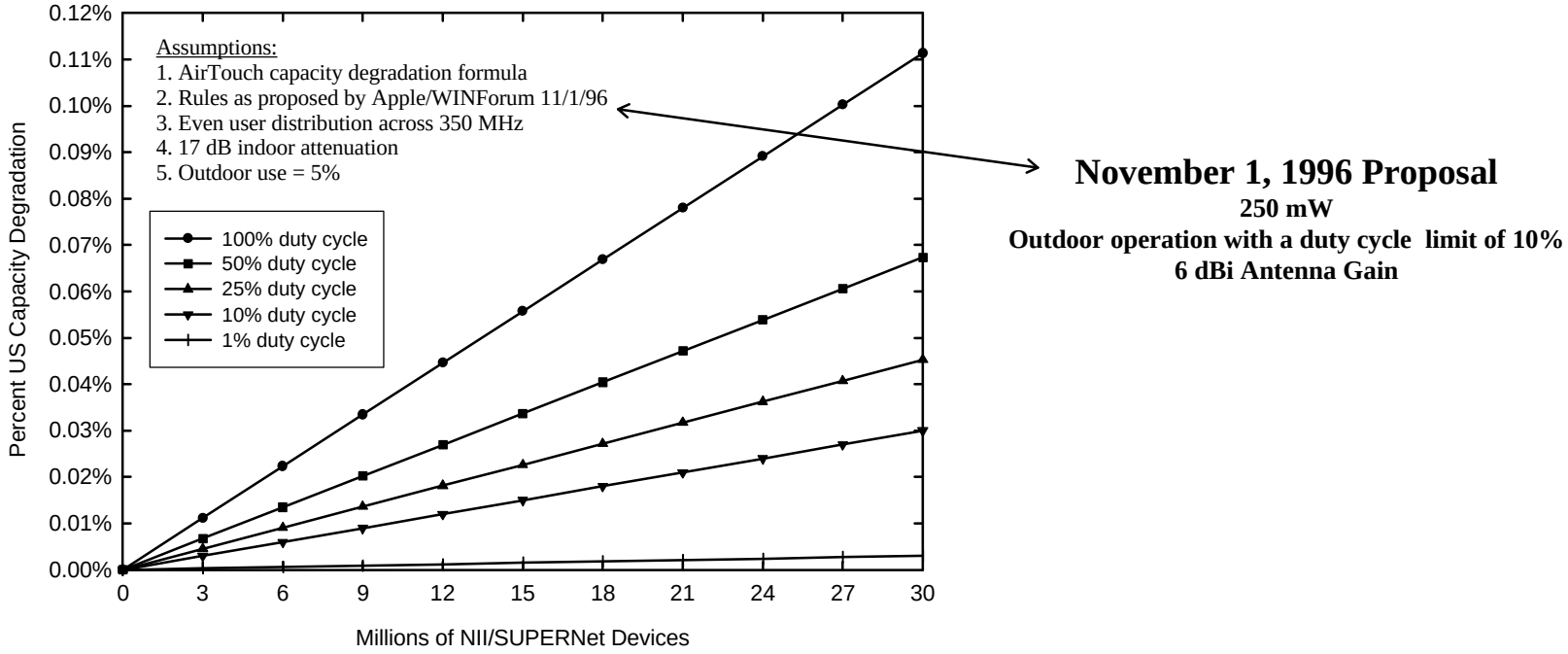


Figure 1: *Globalstar US capacity degradation from NII/SUPERNet devices using the AirTouch formula.*

This Withstood All Technical Scrutiny

Lost the Issue but Gained Credibility at the OET

CURRENT STATE OF THE REGULATIONS

Reconsideration Petition

- Memorandum Opinion and Order Expected by End of Year
- Significant Power Level Issue
- SRDC Ex-Parte in July
- Expect Favorable Resolution about January, 1997
- Described at the July Meeting of 802.11 and BRAN

Lower Band Restrictions

- 50 mW Power Level
- Inside Only

Minimal Sharing Rules

Concern by the NTIA (Next)

NTIA CONCERNS

U-NII Band is Allocated for Government Use

- **Aeronautical Radionavigation**
- **Radio Location Systems**

Impulse Transmission Systems

- **Very Wide Bandwidth Emissions**
- **Cause of Original R&O Power Level and PSD Restrictions**
- **Detailed Investigation by SRDC (See Reference Document 8).**
- **Expect a 13 dB Peak/Burst Average Power Restriction as the Resolution**

RLS Interference to U-NII

- **Very High EIRP Emissions**
- **Wideband LNA Effects**
- **Paper Planned by SRDC - Commitment to Inform Industry of the Threat**

NTIA Participates on the SRDC

THE NEED FOR FURTHER SHARING RULES

The Mixed Bandwidth Phenomena (IEEE P802.11 97-106)

Disadvantage for Wide Bandwidth System Compared to Narrow Bandwidth System

Most Severe for IEEE 802.11 and HIPERLAN type 1 Operation

- **A wide bandwidth receiver tends to sense more narrow bandwidth transmitters when each system has the same spectral use.**
- **The wide bandwidth devices experience a deferral lockout condition.**

Any system using the full signaling rate of the channel experiences condition the first condition.

Systems using procedures that require a quiet channel condition prior to medium access experiences the second condition

This includes IEEE 802.11 and HIPERLAN type 1

Reservation Type Systems are Susceptible if Different Device Signaling Rate Needs Covered in References 5 and 6.

THE NEED FOR FURTHER SHARING RULES

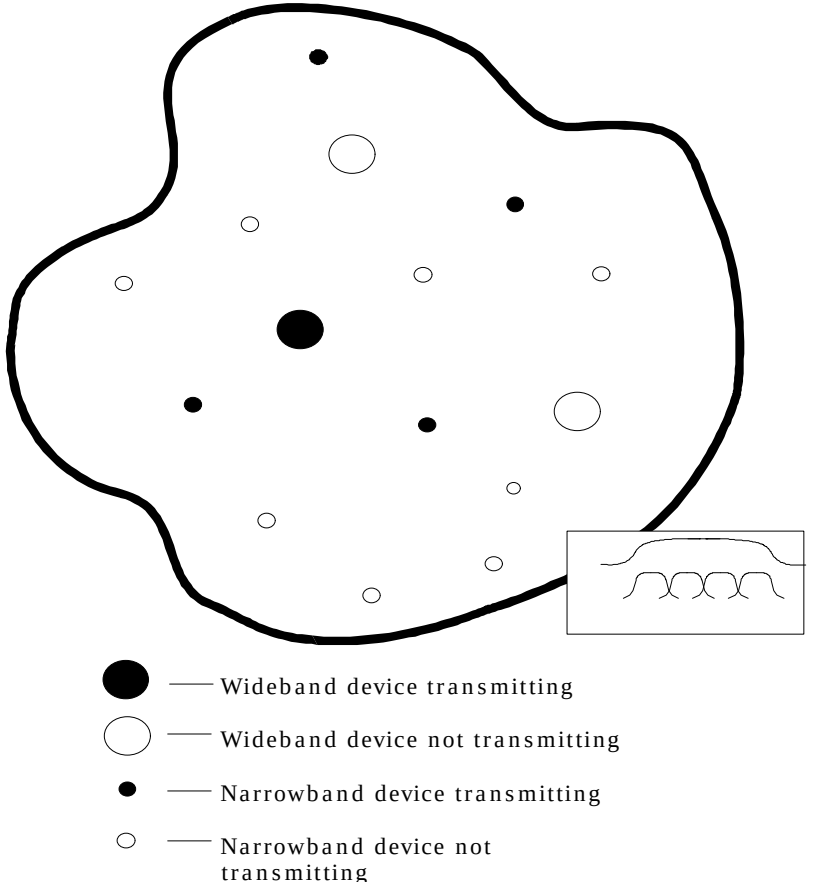
Mixed Bandwidth Comparison (IEEE P802.11 97-106)

Four Narrow Bandwidth Systems in Single Wide Bandwidth Channel

Equal Spectrum Utilization

Four Narrow Bandwidth Devices Per Wide Bandwidth Device Transmitting

The Wide Bandwidth Receiver Can Senses all Narrow Bandwidth Transmitters



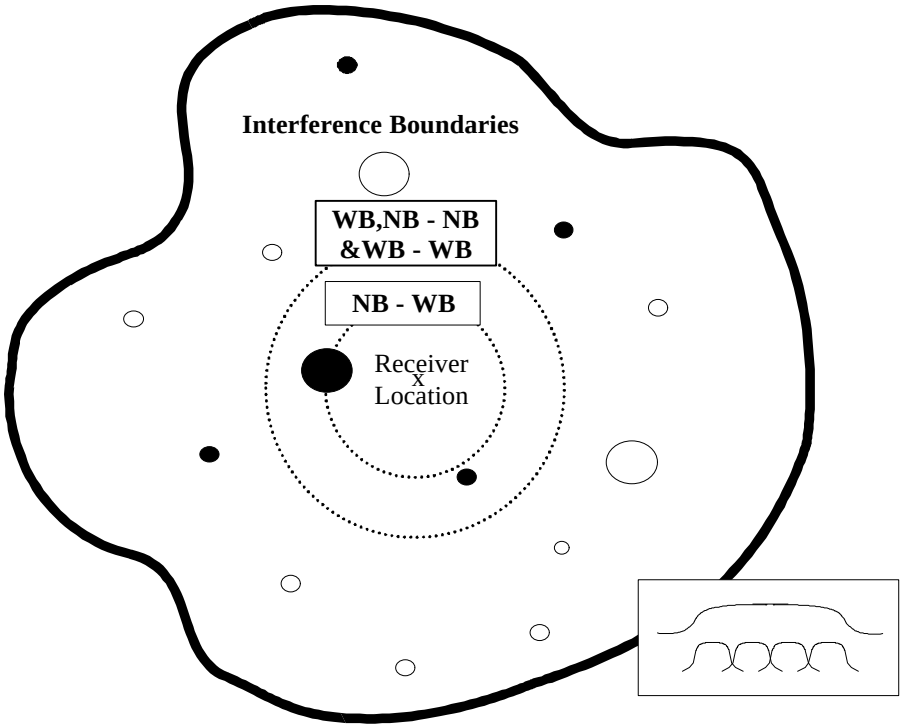
THE NEED FOR FURTHER SHARING RULES

Mixed Bandwidth Comparison (IEEE P802.11 97-106)

If the Signal Detection Threshold Proportional to Bandwidth.

The Interference Range from a Narrow Bandwidth Transmitter to a Wide Bandwidth Receiver is Lower Than to a Narrow Bandwidth Receiver.

The Number of Narrow Bandwidth Transmitters Sensed by a Wide Bandwidth Receiver is Reduced by this Effect.



THE NEED FOR FURTHER SHARING RULES

Mixed Bandwidth Comparison (IEEE P802.11 97-106)

Parameter Definitions

$\frac{P_t}{P_r} \propto r^{\alpha}$ **α is typically = 4 at 5.3 GHz**

xy = 11, 12, 21 and 22.
2 refers to a wideband device or channel and
1 refers to a narrowband device or channel

W = The number of narrow channels within the wide channel

B_x = The bandwidth of channel x (x= 1 or 2)

R = WB_1/B_2 is the packing density of the narrow channels

N_{xy} = The mean number of devices of type y sensed by a type x receiver

97-106 Shows that for N_{12} to Equal N_{21} (when both systems have the same spectrum use) the Power Ratio Must be:

$$\frac{P_1}{P_2} \le \left(\frac{B_1}{RB_2}\right)^{\alpha/2} = W^{-\alpha/2}$$

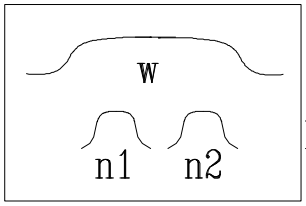
Necessary Condition for Equal Access Capability

Lockout Condition Ignored.

THE NEED FOR FURTHER SHARING RULES

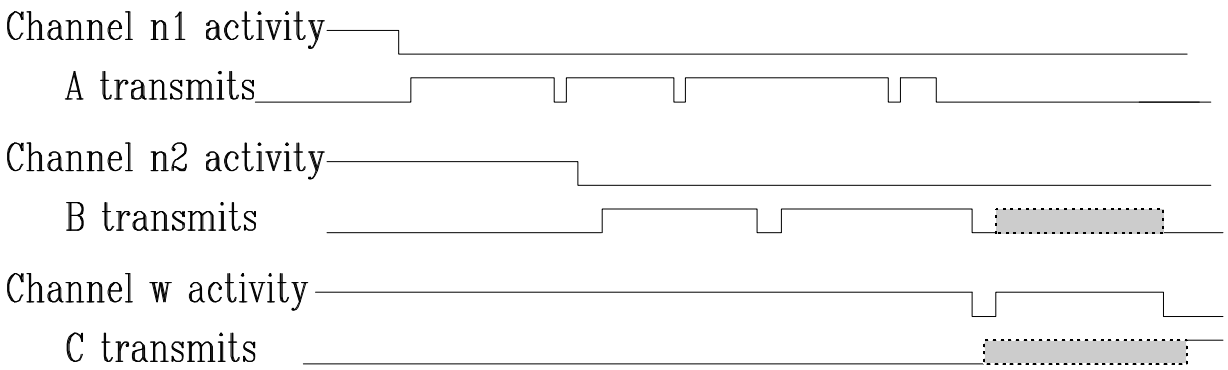
Mixed Bandwidth Comparison (IEEE P802.11 97-106)

The Lockout Problem



Band w **Device C**

Bands n1 and n2 **Devices A and B**



Devices A and B are:

on Different Narrow Bandwidth Channels Within the Channel of Device C and Device C is Within Detection Range of Devices A and B

The Wideband Device (C) Does not Sense an Idle Channel Unless A and B are Idle.

THE NEED FOR FURTHER SHARING RULES

Mixed Bandwidth Comparison (IEEE P802.11 97-106)

The Ratio $N_{21}/N_{11} = \beta$ of 97-106

The mean number of type 1 devices sensed by a type 2 receiver divided by the mean number of type 1 devices sensed by a type 1 receiver.

97-106 Shows that

$$b = R\left(\frac{B_2}{B_1}\right)^{\frac{a-2}{a}}$$

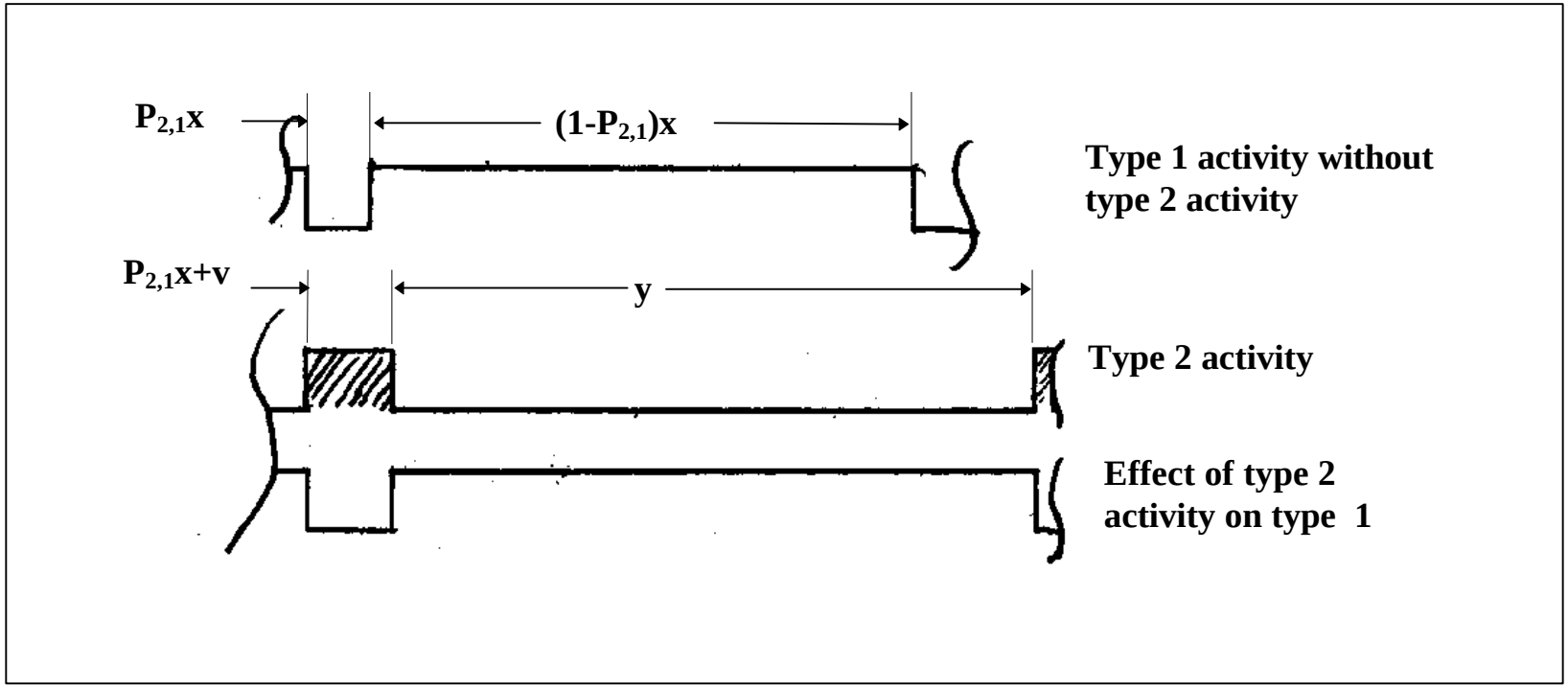
Further, in small areas $\beta = W$ (equivalent $\alpha = \infty$)

$P_{2,1}$ The probability that a wide bandwidth receiver will sense a channel idle condition in the presence of type one transmitters when the type 1 receivers sense an active channel $100N_{11}$ % of the time.

N_{11} is the type 1 system utilization relative to the achievable utilization.

If $N_{11} = 1$, all type 1 channels are always busy.

$P_{2,1}$ as a Function of N_{11} is derived in 97-106. The Following is Figure 7-1 of 97-106



Interaction of Narrowband and Wideband Traffic

THE NEED FOR FURTHER SHARING RULES

Mixed Bandwidth Comparison (IEEE P802.11 97-106)

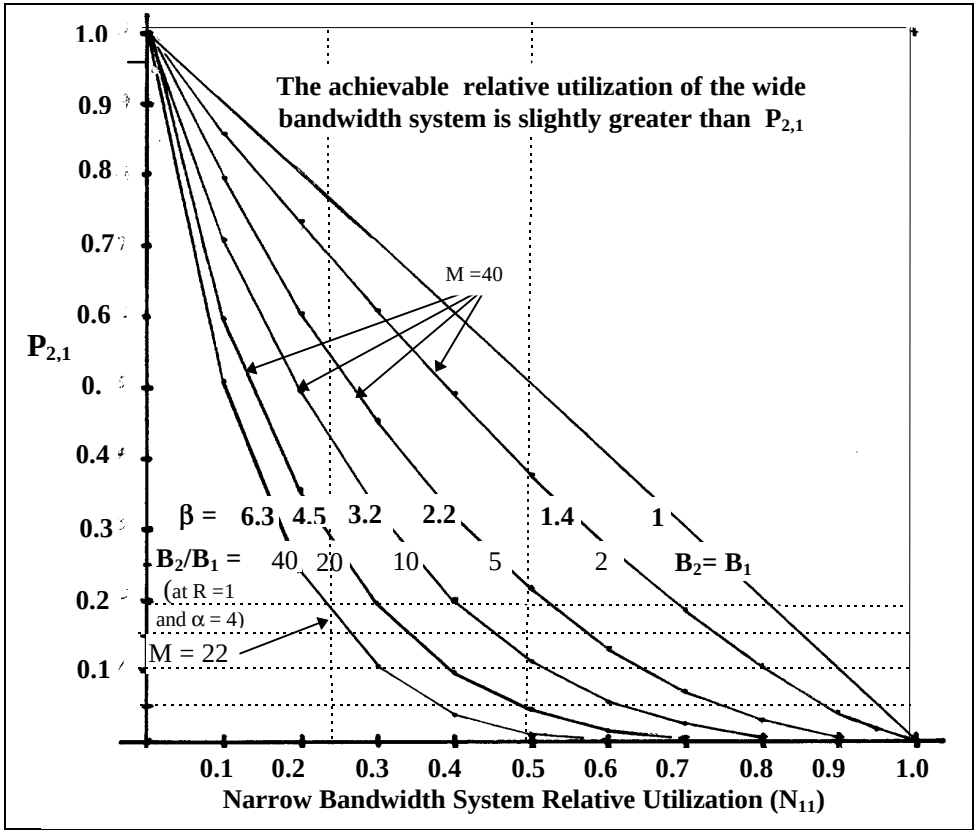


Figure 7-1: The Upper Limit of the Relative Utilization of a Wide Bandwidth System in the Presence of a Narrow Bandwidth System

The wide bandwidth receiver will sense β times as many type 1 transmitters than would a type 1 receiver. Further the type 1 devices are likely to be on different channels and thus create lockout.

Consider the β = 6.3 curve. In small deployment areas this corresponds to a bandwidth ratio of 6.3. Here, the wide bandwidth system is virtually prevented from operation ($P_{2,1}$ = 0.02) if the narrow bandwidth system has a demand of 50% of that achievable.

THE NEED FOR FURTHER SHARING RULES

Non-Standard Systems Coordinate to Defeat the DCF Deference Rules

- **Examples - PCF without a contention interval**
- **DCF with shorter slot time**
- **System without LBT**

May Require

- **Duty cycle limits**
- **Holding time limits**
- **Some level of activity monitoring - not necessarily LBT**

SRDC POSITIONS

Wideband Encouragement

From the SRDC Requirements and Goals Document (Reference 7) :

The U-NII Band Should Support Signaling Rates of at least 20 Mb/s

SRDC Resolution:

“The lower and middle U-NII bands should be channelized with a fixed set of center frequencies”

Rationale presented in Document IEEE P802.11/97-80

Further Work Needed (See P802.11/97-106)

SRDC POSITIONS CONTINUED

Need for Best Effort and Controlled QoS

"The objective of the sharing rules committee is to develop rules that

a) allow the deployment of radio based networks that provide controlled quality of service to their users (examples of controlled QoS protocols that these networks would have to support are ATM and switched Ethernet). Such networks shall be bounded in the amount of channel capacity they may use.

b) provide for smooth (re)distribution of (U-NII) spectrum resources to networks operating within range of each other in a manner consistent with a)

c) provide some (U-NII) spectrum resources for devices that provide a "best effort" type of service or non guaranteed quality of service (e.g. as is the case on the Internet today)."

From the SRDC Requirements and Goals Document (Reference 7)

SRDC POSITIONS CONTINUED

Support for Industry Developed Interoperability Standards

Accepted Resolutions

"SRDC Rules should not preclude IEEE 802.11 or HIPERLAN II from operation in the U-NII bands"

"Assuming an efficient implementation can be identified, it is an objective of SRDC to have sharing rules that will minimize the disruptive interference to IEEE 802.11 and HIPERLAN II type systems"

RECOMMENDATIONS

IEEE 802.11 COPERATE WITH THE SRDC TO DEVELOP SPECTRUM SHARING RULES THAT

- **Permit the IEEE P802.11 to operation in the U-NII bands with a minimum of disruptive Interference**
- **Includes Rules on Bandwidth or Frequency (Document 97-106)**
- **Includes Further Basic Rules to Minimize Disruptive Interference**

RECOGNIZE THE NEED FOR CONTROLLED QOS SYSTEMS WITH SIMILAR SHARING RULES

ESTABLISH A MEANS OF INTERACTION BETWEEN SRDC AND IEEE 802.11 TO ACCOMPLISH THE ABOVE FOR BEST EFFORT SYSTEMS

IEEE P802.11 SUPPORT THE WINFORUM RECONSIDERATION PETITION

Plus any Follow - On That May be Necessary

MIXED BANDWIDTH COMPARISON (IEEE P802.11 97-106)

POTENTIAL SOLUTIONS

1. **Prohibit systems with bandwidths less than B.**
2. **Control the number of narrow channels which can be implemented within a channel width B.**
3. **Restrict the power level of systems with bandwidths less than B.**

Number 2 or 3.

$N_{21}/N_{12} = k$, with $k < 1$ and $T_{12} = T_{21}$ and
same threshold level to thermal noise ratio requires either:

$$\frac{W}{k} \le \left(\frac{B}{B_1}\right)^{\frac{2}{a}}$$ **for the necessary number of channels, and/or**

$$\frac{P_1}{P_2} \le \left(\frac{W}{k}\right)^{\frac{-a}{2}}$$ **as the power level.**

POTENTIAL SOLUTIONS

$$\frac{W}{k} \le \left(\frac{B_2}{B_1}\right)^{\frac{2}{a}}$$

B_2/B_1	W_{max}/k @ $\alpha = 4$	W_{max}/k @ $\alpha = 7.5$	W_{max} @ $\alpha = \infty$
2	1.41	1.20	1
4	2.00	1.34	1
10	3.16	1.45	1
20	4.47	1.54	1

$$\frac{P_1}{P_2} \le \left(\frac{W}{k}\right)^{\frac{-a}{2}}$$

W/k	P_1/P_2 @ $\alpha = 4$ (dB)	P_1/P_2 @ $\alpha = 7.5$ (dB)	P_1/P_2 @ $\alpha = \infty$ (dB)
1	0	0	0
2	-6	-11.3	- ∞
3	-9.5	-17.9	- ∞
4	-12	-22.6	- ∞

POTENTIAL RULES

$\alpha = 7.5$ is candidate column

Possible Combination

$B_1/B > 1/4$, $W < 1.3$

$1.3 < W <= 2$, $P_1/P_2 <= -11$ dB

SRDC Recommends

W < 1 always

Consider a signaling rate limit

Signaling Rate > = B/4

MORE DISCUSSION NEEDED

Reference Documents

1.0 Analysis of the Interaction of Wide Bandwidth and Narrow Bandwidth Systems in the U-NII Band Using the P 802.11 MAC, Don Johnson (IEEE P802.11/97-106)

2.0 Average Antenna Gain Of Part 15 Devices As Seen By A Low Earth Orbit Satellite, Jay Padgett, Attachment to Report of Ex-Parte Meeting with FCC OET of December, 1996.

3.0 Average Antenna Gain for NII/SUPERNet Devices, Don Johnson, Second Attachment to Report of Ex-Parte Meeting with FCC OET of December, 1996.

4.0 The Effect of NII/SUPERNet Devices on Globalstar Capacity, Jay Padgett, December 10, 1997, SRDC/12.10.96.15

5.0 WINForum NPRM Reply Appendix, The Need for Channelization and Procedural Rules for SUPERNet, SRDC Document Number SRDC/09.11.96.10

6.0 Comparative Advantage of Time and Frequency Channelization with Power Proportional to Bandwidth, Don Johnson, SRDC Document Number, SRDC/01.28.97.11

7.0 WINForum Sharing Rules Requirements And Goals, Revision F2, July 18, 1997.

8.0 Wideband Emissions (and) Measurement of Power Spectral Density Using a Spectrum Analyzer, Attachment A to Reconsideration Petition, Jay Padgett., March 1997, SRDC//03.11.97.04