for ease of deployment or managed medium access. In particular, WINForum envisions a distributed medium access control scheme, a centralized medium access control scheme, or a combination thereof:

- In centralized control medium access, one network node, *i.e.*, the Access Point ("AP"), controls which of the nodes is allowed to transmit at any given time. Such permissions to transmit will typically occur in a semi-cyclic fashion. As the AP knows which of its nodes needs service at what frequency it must be assured of access to the medium in a predictable manner. Further, adjacent APs using the centralized mode of operation may be operating on the same channel and some form of time sharing may be needed to allow this to occur.

- In distributed control medium access, all nodes of a network simultaneously contend for access to the channel upon the completion of each transmission. The rate at which a node gains access to the medium is a statistical parameter which is predictable only to the extent that the total load generated by the nodes is below the critical load of the channel. The use of a priority mechanism during contention resolution may be beneficial in allowing traffic with differing importance to be serviced with differing rates of success.

Because SUPERNet will be deployed in both centralized control and distributed control with out reference to neighboring networks and because a limited number of operating channels will be available, a single network may have to share its channel, either with a neighboring network operated by the same user or with a "foreign" network. Hence some kind of channel sharing mechanism is required.

WINForum strongly believes that SUPERNet medium access rules should be developed on the basis of consensus among those in the industry that have an interest in developing, manufacturing, and using SUPERNet products. WINForum has already begun laying the foundation for discussions with many industry members, and will continue to serve as a joint cooperative forum for technical issues. To date, WINForum's technical committee

has already concluded that the common set of access rules, if it is to be capable of supporting the co-existence of systems using centralized and distributed control modes of operation, should address the following:

- Support for three types of information flow -- constant bit rate, variable bit rate and available bit rate services;
- Adaptability to any mixture of information flow types;
- Limitation of continuous transmission time; and,
- Prevention of destructive congestion conditions.

WINForum will continue to advise the Commission on the progress of developing a final shared medium access protocol as work progresses.[11]

V. CONCLUSION

For the foregoing reasons, WINForum respectfully requests the Commission to issue a notice of proposed rulemaking to allocate the 5.1 - 5.35 GHz band for SUPERNet an to adopt technical and medium access rules for SUPERNet. WINForum also requests the Commission to act expeditiously in this matter, in view of the fact that: (1) the requested spectrum segment is of interest to other parties and it is on the agendas of WRC-95 and

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[11] WINForum recognizes that higher level, *e.g.*, product level, compatibility is in the interests of users and manufacturers alike. However, details of performance, modes of operation and detailed protocols are time consuming to define and agreements are difficult to achieve. WINForum accordingly believes consideration of higher level compatibility standards to be outside the scope of an FCC-mandated etiquette. Instead, WINForum suggests that developing standards for compatibility be left to market forces and industry fora, a number of which are already involved in developing voluntary standards for many types of communications and computing equipment.

WRC-97; (2) development of SUPERNet products will require considerable lead time; and, (3) a defined U.S. position on the use of the spectrum segment will help to clarify the position of U.S. based manufacturers with respect to ongoing European HIPERLAN development.

Respectfully submitted,

WIRELESS INFORMATION NETWORKS FORUM

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APPENDIX A: SPECTRUM REQUIREMENTS ANALYSIS

Spectrum Needs Estimate for UPCS

In support of its earlier petition for rulemaking to allocate spectrum for unlicensed PCS devices, WINForum calculated anticipated spectrum requirements for existing applications. These needs were computed on the basis of estimates of voice and data traffic for well known applications in low and high density environments. The results are shown below:

		Low Density Building		High Density Building	
U	kHz/active voice channel	100	-	100	-
T_D	mean date rate, kb/sec/active user	-	60	-	60
I	bandwidth-speed ratio, Hz/bps	1.0	1.3	1.0	1.3
T_V	Erlangs (voice)	0.2	-	0.2	-
E_V	inverse of trunking efficiency (voice)	2	-	2	-
E_V	inverse of protocol efficiency (data)	-	2	-	2
N	reuse factor	15	4	30	10
r	cell radius, ft	50	50	50	50
D	device density, devices/ft^2	0.0054	0.0054	0.0054	0.0054
P	market penetration	100%	100%	100%	100%
S_V, S_D	required spectrum, MHz	21	21	42	42

Data Spectrum Required:

$$S_D = \frac{P}{100\%} \; x \; N \; x \; (2.5 \; x \; r^2) \; x \; D \; x \; E_D \; x \; T_D \; x \; I$$

Voice Spectrum Required:

$$S_V = \frac{P}{100\%} \; x \; U \; x \; N \; x \; (2.5 \; x \; r^2) \; x \; D \; x \; E_V \; x \; T_V \; x \; I$$

"Low Density" and "High Density" are used here to denote environments in which the presence, respectively absence of distances or walls offer isolation between networks or groups of users.

SUPERNet Spectrum Estimates

In developing its spectrum requirements for unlicensed PCS devices, WINForum did not include any consideration of video, interworking with wired networks, or emerging resource-intensive applications using multimedia. In order to conform the prior estimates to typical scenarios using video, WINForum estimated that good quality video now requires at least 1 Mbit/s for 2-way operation (MPEG video requires more than 2 Mb/s). Further, WINForum assumed a demand of 0.1 Erlang, which is 1/2 that assumed for voice, and an inverse trunking/protocol efficiency of 3, which accounts for video interworking with wired networks. The other parameters were deemed equivalent to those used by WINForum for isochronous voice demand. The following table then gives the required spectrum estimate for the video:

		Low Density Building	High Density Building
U	kHz/active user	1000	1000
I	bandwidth-speed ratio, Hz/bps	1.0	1.0
T_{VI}	Erlangs (voice)	0.1	0.1
E_{VI}	inverse of trunking/protocol efficiency	3	3
N	reuse factor	15	30
r	cell radius, ft	50	50
D	device density, devices/ft^2	0.0054	0.0054
P	market penetration	100%	100%
S_{VL}	required spectrum, MHz	152	304

Adding this to the voice and data requirements, the total for low density buildings is 194 MHz and that for high density buildings is 388 MHz.

While an accurate scenario of use is difficult to predict, the above gives a good estimate of what can be accomplished. At the same time, WINForum expects that asynchronous data needs will continue to increase as processing systems become more powerful and information systems become more user friendly. On the other hand, higher efficiency video compression may become viable. Thus, 200 to 300 MHz of HSWDN spectrum will be needed to serve the needs of the coming generation of integrated communication and processing systems.

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Annex to AT&T input to the IAC concerning WARC 97: Sharing studies concerning MSS feeder uplinks and 25 Mb/s High Speed Wireless Data Systems (HSWDS).

Revised December 1994[1]

1 INTRODUCTION

The possibility of MSS feeder links using the 5.2 GHz band for earth to space transmissions from ground stations has been raised. The feasibility of spectrum sharing between MSS feeder systems and HSWDS systems at these frequencies has been investigated by a number of parties. The following is an extract of work [in ETSI] in which AT&T participated.

HSWDS systems are high speed radio data networks providing short range data communications links in the order of 20 Mb/s over ranges up to 50 meters. Typically, HSWDS systems are to be used within buildings but incidental outdoor use has not been ruled out and it is estimated that it will account for approximately 1% of all HSWDS use. HSWDS and similar systems are expected to become the medium of choice for networking portable computer based systems. Spectrum for HSWDS has been allocated within Europe by CEPT in the band 5150 to 5300 MHz. There is also significant interest from the telecommunications and computer industries in obtaining similar spectrum allocations in the United States and other parts of the world. Thus, HSWDS should be treated as a general model for high speed mobile radio data communications world-wide.

One model of MSS have been analyzed: the LEO-48 system which operates at relatively low altitudes and uses wide band modulation (CSMA)

2 CONCLUSIONS AND RECOMMENDATIONS

2.1 Conclusions

The investigation of the sharing between MSS feeder links and HSWDS have resulted in the following conclusions. These are supported by the data and calculations based on LEO-48 system parameters, provided in subsequent sections.

1 MSS satellites of either system would not be affected by the deployment of HSWDS systems, even in very large numbers - e.g. 50 million nodes over the

[1] This revision adds the description and calculations for the ICO-12 satellite. The upper range of the separation distance in the conclusions section of the original annex was based on the ICO-12 satellite but the relevant description and calculations were not included in the text. The revision also corrects an error in a separation distance which was misstated in the conclusions section. The words "9 to 50 km" of 2.1-2 was "3 to 50 km".

area seen by a satellite would not affect the reception of MSS feeder signals at MSS satellites.

2 HSWDS systems could be affected by the MSS ground stations of either system notably in the immediate vicinity of the ground station sites. Typically the required separation distances will be of the order of 9 to 50 km; this depends on local factors. Provided MSS ground station sites are located at appropriate distances from industrial and (sub)urban areas, the deployment of HSWDS systems will not be significantly hampered by the MSS ground stations. The appropriate distances must be determined as part of the site selection process of an MSS ground station.

3 INPUT DATA AND ASSUMPTIONS

3.1 LEO-48

LES EIRP per channel:	54 dBW
allocated bandwidth:	1230 kHz
LES peak Tx antenna gain:	43.5 dB
Satellite Rx sensitivity:	not used
Satellite Rx antenna gain:	- 1 dB
Satellite C/I:	- 2 dB
Satellite Altitude:	1414 km
Assumptions:	
LES antenna pattern:	32 - 25 log θ
maximum range LES to ground station	3940 km

3.2 ICO-12

LES EIRP per channel:	47.5 dBW
allocated bandwidth:	30 kHz
LES peak Tx antenna gain:	47.8 dB
Satellite Rx sensitivity:	not used
Satellite Rx antenna gain:	15 dB at center, 12 dB at edge
Satellite C/I:	15.4 dB
Satellite Altitude:	10355 km
Assumptions:	
LES antenna pattern:	29 - 25 log θ

Maximum range satellite to ground station	15,000 km

3.2 HSWDS

Typical Transmitter power level:	-10 dBW - this includes effects such as dynamic transmitter power control
Typical Interference level tolerated:	-114 dBW - average resulting from dynamic receiver sensitivity control)
Bandwidth:	24 MHz approx.
Assumptions:	
Number of deployed nodes (Europe):	50 M
Active to Passive node ratio:	0.01
Outdoor to Indoor usage ratio:	0.01
Number of RF channels:	3 (overlapping with MSS frequencies)
Building attenuation:	20 dB

3.4 Propagation models

This analysis uses two propagation models:

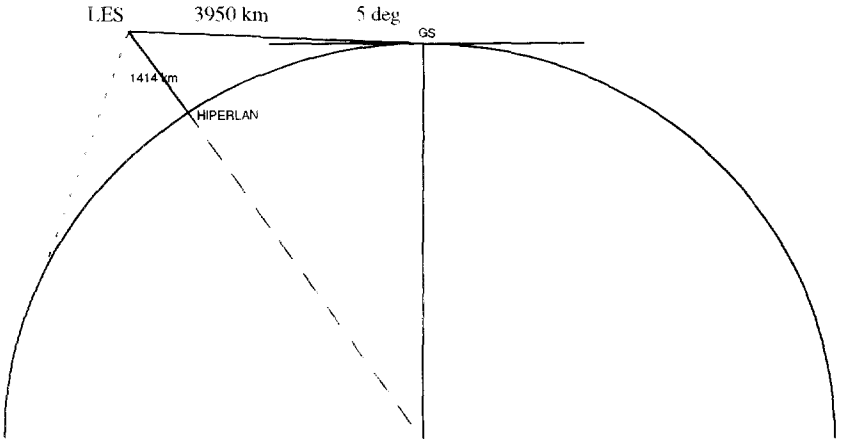
a) - Simple: line of sight, free space: square law
This model is useful for assessing line of sight conditions such as HSWDS to satellite and ground station to horizon.
b) Hybrid: up to 2 km square law, > 2 km third power law
This model has been applied to the propagation between MSS ground stations and HSWDSs below the horizon.

4 CALCULATIONS

4.1 HSWDS to LEO-48 Satellites

4.1.1 Configuration

Satellite directly above HSWDS site and ground station at maximum range (elevation = 5 °)



4.1.2 Calculation

HSWDS - satellite distance:	1,414,000 m
GS - satellite distance:	3,950,000 m
Satellite footprint	4000 KM radius

Path loss HSWDS to satellite: (20log(4pi/lambda) x d)

= 20 log (2.0910**2 x 1,4 10**6)

= 20 log (2.96 x 10**8)

= 169.4 dB

Path loss GS to satellite:

= 20 log (2.09 x 10**2 x 3.95 x 10**6)

= 20 log (9.1 x 10**8)

= 178.2 dB.

Since HSWDS operates on at least 3 channels, only one of these three will interfere with a given uplink channel of the MSS system. This gives a frequency offset ratio of 3.

Power ratio HSWDS/GS	Rp = - 10 dBW - 51.1 dBW = - 61.1 dB
Distance ratio HSWDS/GS:	Rd = -169.4 - (- 178.2) = 8.8 dB
Bandwidth ratio GS/HSWDS:	Rb = (1.27/23) = - 12.5 dB

Interference ratio HSWDS/GS at satellite for outdoor HSWDSs, Ro =
= Rp + Rd + Rb
= - 61.1 + 8.8 - 12.5
= - 64.8 dB

satellite maximum C/I = 15 dB > 49.8 dB "outdoor HSWDS volume tolerance"

Maximum number of active outdoor HSWDS nodes in satellite beam: invlog 49.8 = 95,000

Multiplied by the frequency offset ratio of 3 gives a total of 285,000 active outdoor HSWDSs.

Maximum tolerable outdoor HSWDS population in satellite beam = 28,500,000 nodes

Ratio of indoor to outdoor HSWDS nodes: 100

Total HSWDS population under satellite: 2850 M units approx.

This figure is far in excess of the population visible from a given satellite.

For indoor HSWDSs the building shadowing ratio is assumed to be - 20 dB: This equates to 100 times the outdoor volume.

Alternative analysis of satellite perceived interference

HSWDS to Satellite path loss	-169.4 dB
HSWDS power	20 dBm
Bandwidth ratio	- 12.5 dB
Overall interference level	-161.9 dBm
kTB at 1.27 MHz and 300 degrees K earth temperature	-112.8 dBm
Margin below thermal noise	49.1 dB
Number of nodes outside and directly beneath	81,300
Multiplied by the frequency offset ratio:	243,000

This figure is in the same range as the value for the number of active outdoor HSWDSs derived above.

Conclusion
Even deployed outdoors and directly below a satellite at maximum range from the ground station in numbers that exceed the overall population of the US (or Europe) HSWDS will not affect the minimum C/I at the LEO-48 satellites. Thus HSWDS will not interfere with the uplinks of the LEO-48 satellites.

4.2 LEO-48 LES to HSWDS

4.2.1 Configuration

Ground station pointing in the direction of a HSWDS site.

4.2.2 Calculation

The following table lists the parameters and resulting separation distances required between MSS ground stations and outdoor HSWDS systems for ground station antenna elevations between 5° and 15° and for the typical level of HSWDS sensitivity (which includes the effects of dynamic receiver sensitivity control).

Theta (degrees)	MSS Ant. Gain Rel to Pk (dB)	MSS Tx EIRP (dBW)	HSWDS Sens. Level (dBW)	Range Loss Required (dB)	Separation Free Space (km)	Separation Hybrid (km)
5	-29.0	37.9	-114	151.9	181.3	40.3
10	-36.5	30.4	-114	144.3	76.2	22.6
15	-40.9	26.0	-114	140.0	45.9	16.1

Frequency offset between an MSS uplink and a given HSWDS (which may operate at one of three channels) further reduces the interference: on average, only a third of the HSWDSs in the area covered by the beam will be affected.

The table below shows the same as above but for indoor HSWDSs which experience approximately a 20 dB lower interference level due to building attenuation factors

Theta (degrees)	MSS Ant. Gain Rel to Pk (dB)	MSS Tx EIRP (dBW)	HSWDS Sens. Level (dBW)	Range Loss Required (dB)	Separation Free Space (km)	Separation Hybrid (km)
5	-29.0	37.9	-94	131.9	18.1	8.7
10	-36.5	30.3	-94	124.3	7.6	4.9
15	-40.9	26.0	-94	120.0	4.6	3.5

Frequency offset between an MSS uplink and a given HSWDS (which may operate at one of three channels) further reduces the interference in a given area.

Conclusion

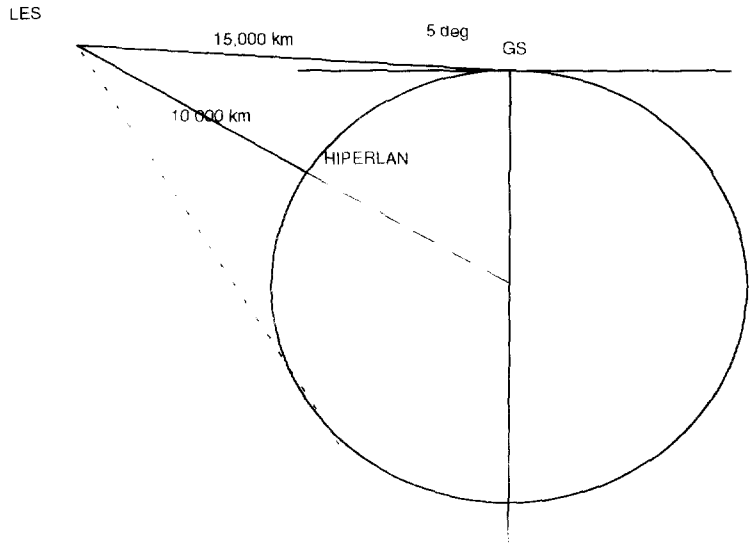
The ground station transmitters will interfere with indoor HSWDS receivers at ranges up to 8.7. km assuming the 2 km/+ propagation model. HSWDSs within line of sight of the ground station will suffer interference at up to 40.3 km from the ground station - which is typically beyond the horizon of a typical ground station site. Using the free space model this distance is even larger.

The beam dwell times are significant due to the level of the side lobes. Assuming a 60 sec /degree elevation rate, HSWDS sites that are interfered with at all will see interference from the ground station for at least 10 minutes while the beam is pointing in their direction. This will happen several times per day and could cause unacceptable reduction in service to HSWDS users under these conditions only.

4.3 HSWDS to ICO-12 Satellites

4.3.1 Configuration

Satellite directly above HSWDS site and ground station at maximum range (elevation = 5 deg).



4.3.2 Calculation

HSWDS - satellite distance: 10,000 km
GS - satellite distance: 15,000 km

Path loss HSWDS to satellite:
= 20 log (2.09 x 10**2 X 10**7)
= 20 log (2.09 x 10**9)
= 186.4 dB

Path loss GS to satellite: (20log(4pi/lambda) x d)
= 20 log (2.0910**2 x 1.5 10**7)
= 20 log (3.14 x 10**9)
= 189.9 dB

Power ratio HSWDS/GS	Rp = - 10 dBW - 47.5 dBW - = - 57.5 dB
Distance ratio HSWDS/GS:	Rd = - 186.4 - (-189.5) = 3.5 dB
Bandwidth ratio GS/HSWDS:	Rb = .03 / 24 = - 29. dB

Interference ratio (for each MSS channel) between outdoor HSWDS/GS at satellite, Ro:
= Rp + Rd + Rb
= - 57.5 + 3.5 - 29.5
= - 83 dB

Satellite maximum C/I = 15.4 dB -> 67.6 dB "outdoor HSWDS volume tolerance"

Maximum number of active HSWDS nodes in satellite beam: invlog 67.6 = 5,700,000 units

Multiplied by the frequency offset ratio: 17,100,000 nodes

Maximum tolerable outdoor HSWDS population in satellite beam = 1710,000,000 nodes. This figure is larger than the population visible from a given satellite.

The number of indoor HSWDS is another factor 100 higher.

Conclusion

Even with numbers of HSWDS nodes that exceed the overall population of the US and Europe deployed directly below a satellite at maximum range from the ground station the minimum C/I at the ICO-12 satellites is preserved. Thus HSWDS will not interfere with the uplinks of the ICO-12 satellites.

4.4 ICO-12 LES to HSWDS

4.4.1 Configuration

Ground station pointing in the direction of a HSWDS site.

4.4.2 Calculation

The following table lists the parameters and resulting separation distances required between MSS ground stations and outdoor HSWDS systems for ground station antenna elevations between 5° and 15° and the typical level of HSWDS sensitivity (which includes the effects of dynamic receiver sensitivity control).

Theta (degrees)	MSS Ant. Gain Rel to Pk (dB)	MSS Tx EIRP (dBW)	HSWDS Interference Level (dBW)	Range Loss Required (dB)	Separation Free Space (km)	Separation Hybrid (km)
5	-36.3	40.4	-114	154.4	252.2	50.3
10	-43.8	32.9	-114	146.9	106.0	28.2
15	-48.2	28.5	-114	142.5	63.9	20.1

Frequency offset between an MSS uplink and a given HSWDS (which may operate at one of three channels) further reduces the interference: on average, only a third of the HSWDSs in the area covered by the beam will be affected.

The table below shows the same as above but for indoor HSWDSs which experience approximately a 20 dB lower interference level due to building attenuation factors

Theta (degrees)	MSS Ant. Gain Rel to Pk (dB)	MSS Tx EIRP (dBW)	HSWDS Sens. Level (dBW)	Range Loss Required (dB)	Separation Free Space (km)	Separation Hybrid (km)
5	-36.3	40.4	-94	134.4	25.2	10.8
10	-43.8	32.9	-94	126.9	10.6	6.1
15	-48.2	28.5	-94	122.5	6.4	4.3

Conclusion

The ground station transmitters will interfere with indoor HSWDS receivers at ranges up to 10.8 km (assuming the 2 km/+ propagation model). Outdoor HSWDSs within line of sight of the ground station will suffer at up to 50.3 km from the ground station - which is significantly beyond the horizon of a typical ground station site. Using the free space model this distance is even larger.

The beam dwell times are significant due to the level of the side lobes. Assuming a 60 sec /degree elevation rate, HSWDS sites that are interfered with at all will see interference from the ground station for at least 10 minutes while the beam is pointing in their direction. This will happen several times per day and could cause unacceptable reduction in service to HSWDS users under these conditions only.

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APPENDIX C - ETSI HIPERLAN

The HIPERLAN standard being developed by ETSI is targeted at wireless LAN applications and does not support all the types of services projected for SUPERNet. Nevertheless, HIPERLAN provides an interesting model for the distributed mode of SUPERNet.

Background

In December 1992, the European frequency regulators ("CEPT") published a Recommendation (T/R 22-06) that allocated the 5150 to 5300 MHz range to "HIPERLAN", the provisional name for a system specification to be developed by the European Telecommunications Standards Institute ("ETSI"), covering applications that are very similar to those identified for SUPERNet. The CEPT recommendation gave HIPERLAN systems a non-protected, non-interference status, but included the statement that member nations should avoid letting other systems or services into the band. Since then, ETSI has developed the first version of the HIPERLAN specification, which was aimed at ad-hoc networking. Work on a second mode, aimed at supporting controlled admission and high quality of services, has been initiated.

The HIPERLAN standard developed by ETSI -- with American based companies like Apple, AT&T and IBM -- contains an innovative multiple access scheme that provides a graded service driven by the "packet life time." This allows HIPERLAN to support services with different quality of service requirements, including multi-media services. The first version of the standard is designed for ad-hoc networking. It does not provide for admission control and thus the overall quality of service is highly dependent on the number of active devices in a given area. A second version is being considered which is to address that problem in the context of centrally controlled radio networks based on wire connected access points and a different medium access scheme that retains compatibility with the first version. In the following, "HIPERLAN" refers to the first version, unless noted otherwise.

Table A1: HIPERLAN Target Parameters

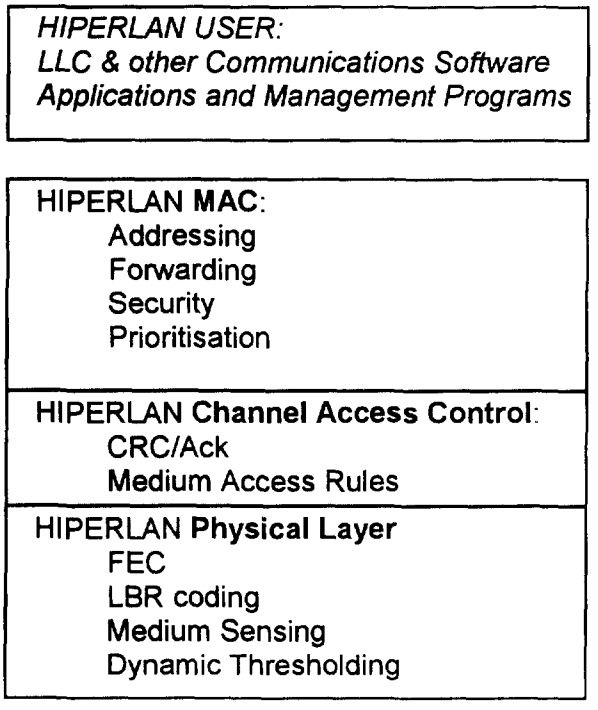
Service Types:		Asynchronous and "time bounded";
Data Rates		
	Asynchronous:	1 to 20 Mbit/s;
	Isochronous:	64 kbit/s to 2048 kbit/s;
Systems Throughput:		~150 Mbits/second per hectare per floor;
Typical Latency		
	Asynchronous:	< 3 milliseconds
	Isochronous:	< 3 seconds
Service Delay		
	Asynchronous:	variable;
	Isochronous:	< 3 milliseconds maximum;
Range:		50 meters;
Coverage:		> 99.9 percent in space and time;
Co-Location Tolerance:		1 meter free space;
Mobility Tolerance:		3 meters/s linear, 1 Hz angular.

Target Markets & Requirements

HIPERLAN, in its first version, is aimed at a variety of applications and markets. The main target markets are those where ad-hoc deployment and high capacity are required or desirable. The requirements originally developed for HIPERLAN are summarized in the table above.

Architecture

The HIPERLAN standard defines a communications subsystem consisting of a physical services (PHY) layer, the radio subsystem, and a medium access control (MAC) layer. The MAC layer includes a number of interesting features that support the ad-hoc deployment of HIPERLAN: it provides the ability to dynamically detect the presence of other networks and to forward frames between the nodes of an ad-hoc network. These functions are separated from the detailed medium access mechanisms that have been incorporated into a sublayer of the MAC called Channel Access Control. The architecture of HIPERLAN is pictured in the diagram below:



Spectrum Use and Systems Capacity

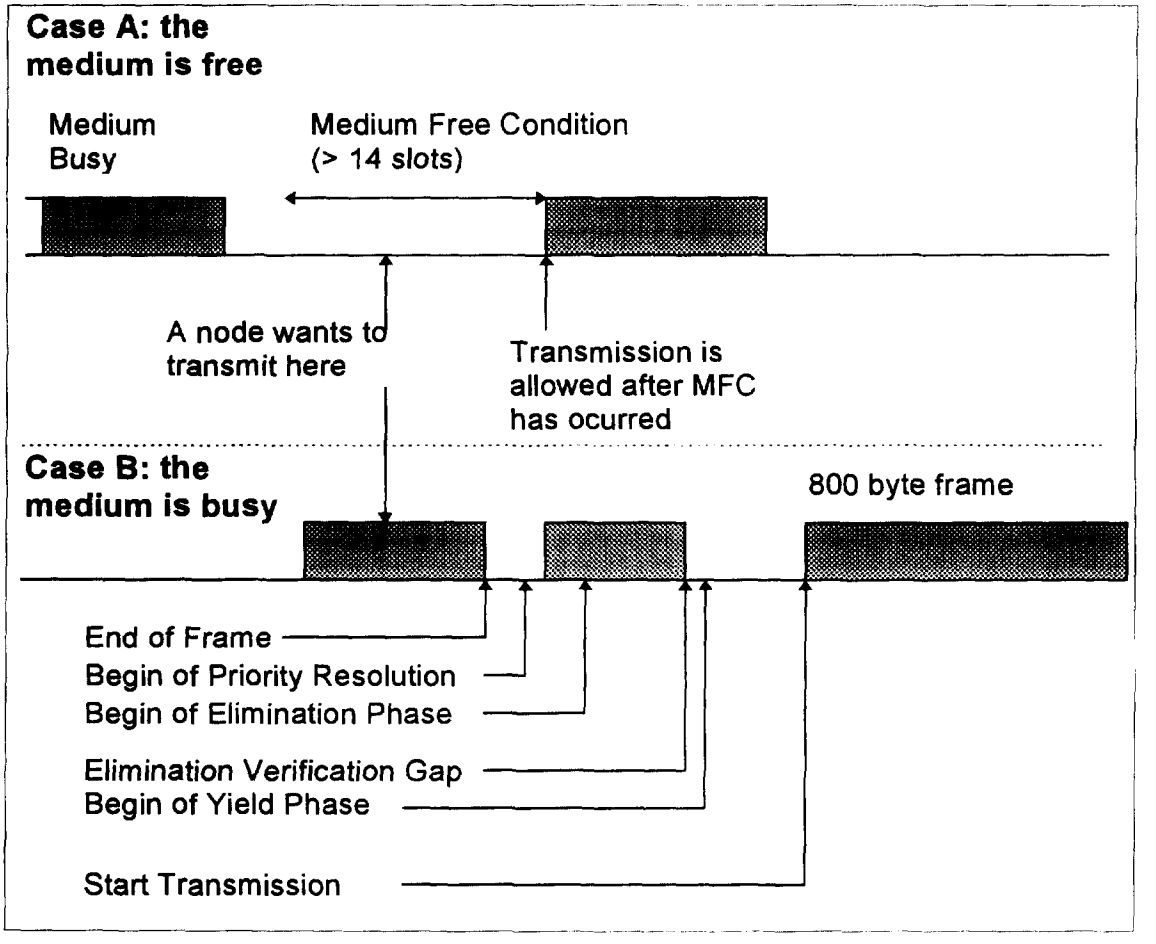
The HIPERLAN standard specifies five channels spaced at 23.5 MHz in the 5150 to 5300 MHz frequency range allocated to HIPERLAN systems by CEPT T/R 22-06. GMSK has been chosen for version I and hence full channel separation is not achieved. However, given the channel access rules, HIPERLANs operating at adjacent channels will defer to each other in case of close co-location resulting in potentially high interference levels.

HIPERLAN offers a bitrate of 23.5 Mb/s in each of the five channels. Forward error correction with a 26/31 expansion rate is used to enhance the basic bit error rate. The raw systems capacity of HIPERLAN is therefore about 120 Mb/s in a given area. The effective throughput however, is reduced by the channel access mechanism.

Channel Access Mechanism

The HIPERLAN channel access mechanism is designed to operate effectively in uncoordinated networks. A two phase contention reduction scheme with a residual collision rate of three percent (an optimum found by extensive simulation) is preceded by a priority sorting phase from which only nodes with equal priority survive. The contention reduction scheme uses geometric probability distributions in order to keep the time needed to select a survivor within limits: the overhead of the scheme varies a the logarithm of the number of nodes.

The overall scheme is represented below. The medium in sensed in medium sensing slots. The length of these slots varies with the phase in which they are used. In the Priority Resolution and Elimination Phases, Tx/Rx turnaround is required and here the slot is 10 microseconds. In the Yield Phase the slot is 5 microseconds.



The maximum number of slots in the Priority Resolution Phase is 5, in the Elimination Phase it is 14, in the Yield Phase it is 12. Typically 3 slots will be needed for priority resolution, 3.4 for Elimination and 6 for Yield. Taking all other overhead such as low bit rate header and Ack into account gives an efficiency of about 55% for an average user data length of 800 bytes.

It should be noted that the above medium access mechanism has no means of regulating channel access by nodes -- the performance of each node depends on the number of nodes active in a given area and on the level of activity of each of the active nodes. The implication is that a HIPERLAN based wireless system cannot guarantee service -- it can only operate on a best effort basis. This means in practice that an expensive long distance connection terminating in a wireless link may have to defer to a local file transfer started up in the vicinity.

Other Features

Quality of Service and Medium Access Priority Mapping

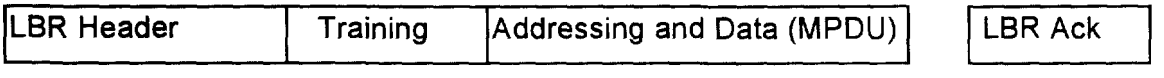
The HIPERLAN user can specify priority ("high" or "normal") and time-to-live (0 - 500 milliseconds) for a data packet presented to the HIPERLAN MAC. Priority and time-to-live are mapped onto *four levels of medium access priority*. The time-to-live is decremented until the packet is transmitted. If it reaches zero before the packet is transmitted, the packet is discarded (and the HIPERLAN user is informed of this fact).

Residual Time-to-Live (RTtL)	User Priority = High	User Priority = Low
RTtL ≤ 10 ms	0	1
10 ms ≤ RTtL ≤ 20 ms	1	2
20 ms ≤ RTtL ≤ 40 ms	2	3
40 ms ≤ RTtL ≤ 80 ms	3	4
80 ms ≤ RTtL	4	4

The effect of this scheme is that -- while the local channel load is below the critical level -- the packets with the lowest time to live get transmitted first. Thus, the user can influence the service seen by an individual packet by setting the time-to-live parameter appropriately. However, as the channel load increases above the critical level, the channel access delay increases rapidly and the time-to-live of more and more packets will decrement to zero causing these packets to be thrown away. Time-to-live and re-transmission are linked and, where re-transmission is relevant, may require management at higher layers.

Low Bit Rate Header and Acknowledgment.

In order to save power, the equalizer is used only during the reception of "user data." System signaling at a low bit rate (1 Mb/s) is used to carry the destination address (for unicasts and multicasts that allows the destination node to switch on its equalizer. Similarly, the Ack contains the address, coded at the low bitrate, of the source of the frame and does not require equalisation.



Forwarding

The HIPERLAN specification defines topology information and rules for its exchange between nodes such that certain nodes can provide forwarding services for other nodes. The role of *Forwarder* is defined as additional to the basic node behavior. Selection of nodes for forwarding is a deployment issue.

Power Conservation

The HIPERLAN specification a power conservation mechanism based on sleep/wake patterns. It defines protocol elements that allow nodes to establish time reference for such patterns and to inform other nodes about their own pattern relative to the reference.

LAN Interworking

HIPERLAN addressing is identical to IEEE 802.3 addressing and the HIPERLAN protocol specification allows HIPERLAN based systems to interwork with one or more external LANs.

Security

The HIPERLAN standard contains a specification for an algorithm and procedure that serve to encrypt the user data transmitted within a logically closed network. Only members of such a network can decrypt the packets. However, key management is outside the scope of the standard.