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Re:	This contribution is submitted in response to call for contributions from the WirelessHUMAN study group chair for submissions of requirements for WirelessHUMAN systems, Session #7.
Abstract	This document outlines the basic requirements of a fixed BWA system operating in the 5GHz UNII bands. Basic characteristics and limitations of the frequency bands are analyzed, and suitability of some systems (802.11a, 802.16.1 and 802.16.3) for the BWA is speculated. A system model to be used as the basis of the study group work is proposed.
Purpose	Contribution to initiate discussion at the upcoming 802.16 Session #7 in Gaithersburg, MD (May 1-5, 2000).
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Requirements for WirelessHUMAN Systems

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Introduction

This document deals with the basic questions of the WirelessHUMAN group:

- What are the motivations for this standardization effort?
- What are the applications and their requirements?
- What are the features of UNII bands?
- How to meet all these requirements?
- Where does WirelessHUMAN fit in the 802 hierarchy?

Answers to all these questions are structured in the following format. First, we present the main target markets and related system requirements and limitations, followed by a list of requirements set by the 5 GHz frequency band. After defining the system requirements from both customer needs and frequency characteristics, we can speculate with the suitability of some of the systems (802.11, 802.16.1 and 802.16.3) for fixed BWA on the given frequency band. The analysis will be concluded by a proposal of a top-level system model for the basis of the further work in the group. Additionally we give a proposal for a way to continue work targeting a standard for fixed BWA systems on 5 GHz UNII bands.

Motivation for Standardization from a BFWA and WLAN perspective

From the BFWA players perspective, standardization offers the usual advantage: interoperability leading to accelerated market growth. From the WLAN players perspective, who have a vested interest in protecting 802.11a, seeing the advantages of this standardization effort is less obvious, though not less significant. To realize this, it should first be noted that manufacturers and providers will offer BFWA solutions in the UNII bands irrespective of the existence of an IEEE standard. Without an IEEE standard, after all, a few of the biggest players will likely end up setting defacto standards.

Therefor, the IEEE WLAN community, in its unique position to thwart UNII-BFWA standardization, merely has the choice between unbridled unstandardized equipment deployment, the interference of which onto WLAN products will be uncontrollable and irrelevant from the BWFA manufacturers and providers perspective, or it has the choice to actively participate in the standards development, in order to ensure graceful co-existence. As manufacturers tend to gravitate towards standardized products, for the reasons mentioned above, the result will lead to significantly less interference issues between both types of devices.

This standardization effort is further in the interest of both the WLAN and BFWA communities as a shared or near-identical PHY layer (which we motivate below) increases chip-set volumes and hence reduces cost for both products.

Market demands

Before going into a detailed analysis of system requirements, we have to decide on the targeted markets. The other set of limitations and requirements from the frequency band under study is presented in the following chapter.

The set of main customers is to a large extent the same as in 802.16.3 containing residential and SOHO customers. Additionally, due to the nature of the unlicensed bands, new customer groups like private ISPs providing services will be interested in providing easy and fast access to Internet with competitive pricing. The attraction of the UNII bands is that they allow fast and easy start-up and expansion of access networks, as they lacks both the necessity of tedious expensive bandwidth acquisition and time-consuming permit requirements. This is one of the main features that should be preserved and enabled by the standard. It would therefor be a serious mistake to tie up the standard to topologies that exclusively mandate highly directional antennas which would require professional installation of each and every CPE. This would not only defeat the installation ease and prohibit easy system expansion, but also boost the cost-to-customer to unacceptable levels, as human resource costs equate about half of the cost-to-consumer. In a market where BFWA must compete with xDSL and cable modems, such huge cost increases will be unsustainable.

Of course, it's not only installation cost that matters. The equipment cost, accounting for about a quarter of the cost-to-consumer, has to be low enough as well. In license exempt bands with low transmission power (i.e. short range) the access network becomes naturally relatively dense and the price of CPEs really matters. The only practical way to assure cost effective equipment for the license exempt bands on 5 GHz is to use mass-produced chip-sets that are either already in the market or coming in the near future. This will definitely result in devices at minor silicon cost and significant cost-reduction to both service provider and end-user. Together with the ease of installation, this will enable the success of WirelessHUMAN systems.

Characteristics of 5 GHz UNII bands

The UNII bands come with strict low regulatory limitations on EIRP, which either results in systems with very limited ranges, or in systems with large very high-gain antennas. In the first case, a very dense deployment of pure PMP base-stations would be required, resulting in a very expensive infrastructure cost (dominated by site acquisition cost). In the second case, the antennas would not only be exceedingly expensive, but generally too large to be tolerated in residential areas by all kinds of local aesthetics committees (comparable to the widespread resistance against satellite dishes).

In urban and sub-urban environments, which form the core of the target markets, a pure PMP deployment will lead to a significant percentage of NLOS customer sites (in excess of 25%) with severe multipath as a result. Compared to the WLAN PHY, the targeted links are orders of magnitudes larger, and hence multipath mitigation must be more seriously considered.

Currently, the only standard for the UNII bands is the 802.11a WLAN standard. In the interest of both the WLAN and BFWA communities, the BFWA standard should be made to gracefully co-exist with 802.11a. However, non-standardized equipment will also find its way into these bands, hence requiring measures of interference resilience/avoidance. Therefor, there’s a strong need for dynamic frequency selection (DFS), transmission power control (TPC) as well as adaptive modulation.

WirelessHUMAN with existing systems?

Although the 802.16.1 standardization is still in an initial phase, it has already become quite clear that the requirements resultant from the targeted markets are significantly different. In addition, the characteristics of the bands addressed by 802.16.1 are so different, that the requirements derived from this make the 802.16.1 standard entirely unsuitable as starting point or model for WirelessHUMAN.

The PHY and MAC of 802.16.3, although yet entirely undefined, will be designed for bands with significantly higher tolerated EIRP and entirely different interference concerns, since 802.16.3 caters to licensed bands where

interference is relatively non-existent. It is hence questionable, whether this standard would provide an adequate solution for the UNII bands.

The PHY of 802.11a (and HiperLAN/2) is mainly designed for the UNII bands, and fairly suitable for multipath mitigation. As stated before, especially with regard to co-existence issues, it would be an attractive selection. Economy of scale, resultant from the sharing of chip-sets, provides an attractive means of cost-reduction.

The MAC of 802.11a, however, is designed for totally different usage and deployment scenarios with portable stations. It has not been optimized to provide fixed wireless access to stationary nodes. Additionally, it is defined initially for the ISM bands, which has resulted in solutions not suitable for BFWA.

System model for WirelessHUMAN

From the requirements set by the BFWA market and the 5 GHz UNII bands a set of main features of the WirelessHUMAN system model can be sketched out. First, it should enable

- co-existence with 802.11a
  - interference avoidance by DFS and TPC
  - interference resilience by adaptive modulation
- low cost, mass-market devices (especially CPEs enabling cheap antenna solutions)
- high coverage ratio for the targeted area

Most importantly, the standard should be written such that compliant devices have at least one narrowly well-defined mode which guarantees at least minimal interoperability of all compliant devices.

Additionally, the system must provide QoS support and standardized authentication, authorization and network entry protocols to enable plug-and-play capability.

On the system architecture level, the rescalability is the essential factor. The system should allow easy customer installation of CPEs and it should be easily expanded. Secondly, no single network topology is suitable for all the deployment scenarios of the presumed customers. Thus the WirelessHUMAN system should enable flexible topologies and should not be limited to one fixed solution.

No existing system can fulfil all these requirements and provide all the features as such. There is a need for a new system specification. Whether some PHY components of the existing systems could be used in the WirelessHUMAN system should be further studied. Currently, from both the co-existence and economical point of view, the 802.11a PHY seems the most attractive one for the basis of the system under study. For the MAC there seem to be no attractive solution in the existing systems.

As the basis of the further work a system model shown in Figure 1 is proposed. It does contain all the elements listed above and provides the capability to flexibly adjust the network to meet the customer/operator needs. From the co-existence point of view the system should be based on a common PHY and related protocols, like DFS and TPC. On the MAC layer we should further study the possibility of MAC solutions supporting various network topologies.

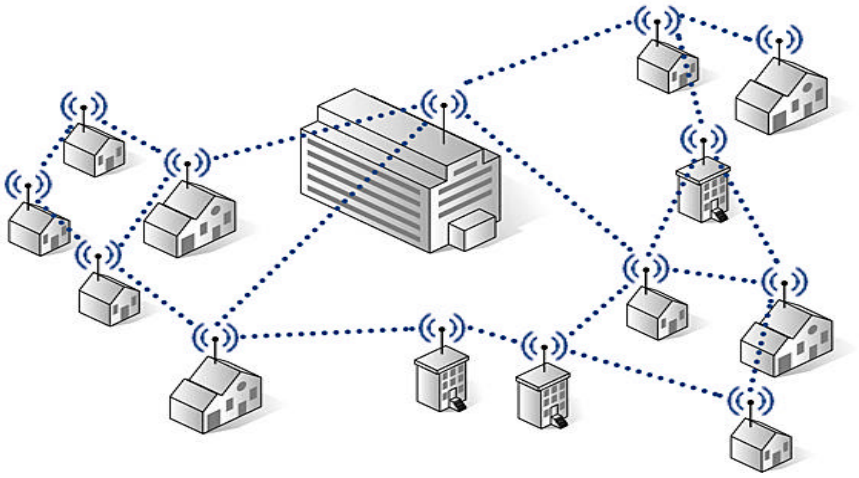

Figure 1. Proposed WirelessHUMAN System Model.

WirelessHUMAN in the 802 standardization hierarchy

In order to standardize WirelessHUMAN, it would be most effective to place it under the joint leadership of 802.11 and 802.16. This will not only improve the co-existence considerations between WirelessHUMAN and 802.11a standards, but will also release the standardization from the strictly LMDS band oriented PAR guiding 802.16, which is, as was argued above, too rigid and not intended for unlicensed bands. As it is not a LAN standard, placing it entirely under 802.11 would be inappropriate, especially since the interested parties between the two groups are partly different. Furthermore, this might create practical problems with maintaining membership status in either group.

Conclusions

The purpose of the document was to deal with the basic questions of the WirelessHUMAN study group: why, what, and how. First, reasons for the standardization effort in IEEE were presented. It was noted that there will most likely be BFWA systems on 5 GHz UNII bands irrespectively of the existence of an IEEE standard. By standardizing the WirelessHUMAN system jointly with 802.11 a graceful co-existence with 5 GHz WLAN devices will be ensured.

The second question was dealt with analysis of both market demands and 5 GHz band characteristics. From the former one three major requirements came up: easy CPE installation, easy system expansion, and low-cost CPEs. Regarding the 5 GHz UNII bands it was noted that they are ruled by strict low regulatory limitations on EIRP, which will result in either very dense network or very high-gain antennas. Both of the cases were shortly analyzed, as well as the demands from the co-existing 802.11a.

The requirements from the market and the UNII bands were mapped onto the system requirements in the section concentrating on the question how. It was noted that the focus should be on a rescalable system architecture, which allows easy customer-installation of CPEs. To ensure this goal the system should enable flexible topologies and shouldn't be limited to single one. e.g. PMP.

As the basis of the further work a WirelessHUMAN system model is proposed. It is proposed to be used in the further studies, which should be continued jointly with 802.11 community. It was noted that no existing system is suitable for providing fixed broadband wireless access on 5 GHz UNII bands. Thus the study group should continue the work aiming for an IEEE 802 standard for WirelessHUMAN systems. The work is proposed to be

continued with more thorough system analysis work, which should result in a PAR latest in July 2000, if necessary by introducing interim meetings.