HIPERLAN channel assignment strategies

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HIPERLAN (high performance radio local area network) (type 1) is an ETSI high speed wireless LAN standard. The simulation results presented suggest that the best RSSI-based HIPERLAN channel assignment strategy is to always choose the channel with the lowest amount of measured interference, rather than the first channel measured below the clear channel assessment (CCA) threshold.

Introduction: HIPERLAN (high performance radio local area network) is a wireless LAN standard recently adopted by the European Telecommunications Standards Institute (ETSI) [1]. HIPERLAN (type 1) operates in 150MHz of spectrum in the 5.15–5.30GHz band, with five TDD channels capable of data transmission at speeds of up to 23.5Mbit/s.

HIPERLAN uses a (31, 26) BCH code to encode data to be transmitted into 31bit segments, and Gaussian minimum shift keying (GMSK) with $BT = 0.3$ to modulate these encoded bits for transmission over the air at a high bit rate (23.5Mbit/s).

Each HIPERLAN cell site or hub may transmit on any HIPERLAN channel, however the hub and all terminals within the cell operate on only one RF channel at any given time. Only one terminal in each HIPERLAN cell may transmit a packet at a time. The hub RF channel may be chosen dynamically in accordance with the HIPERLAN clear channel assessment (CCA) scheme [1].

The CCA scheme flags a channel as being ‘free’ if < –75dBm of RF energy (RSSI or received signal strength indication) is detected in that channel. HIPERLAN includes the provision for the CCA threshold (CCAT) to be increased to above –75dBm, but not lowered. This Letter examines the impact of lowering the CCAT below –75dBm.

HIPERLAN packet error estimation: The probability of bit error P_B for GMSK in the presence of AGWN was derived by Murota and Hirade [2]. Expressed in terms of the Q function, P_B is given by

$$P_b = Q\left(\sqrt{\frac{d^2_{min}}{2N_0}}\right) \qquad (1)$$

where d_{MIN} is the minimum value of the signal distance between mark and space in Hilbert space, and is related to BT. Murota [2] published a plot of $d^2_{MIN}/2E_B$ against BT for GMSK. For HIPERLAN, $BT = 0.3$ and from the plot, $d^2_{MIN}/2E_B \simeq 1.8$. Hence P_B is given by

$$P_b \simeq Q\left(1.342\sqrt{\frac{E_b}{N_0}}\right) \qquad (2)$$

The (31, 26) BCH code can detect three bit errors and correct one, hence the probability of a packet error P_P in the 31 bit BCH encoded segment is given by

$$P_p = 1 - (1 - P_e)^{30} \qquad (3)$$

In a simulation, the C/I at the input to a particular receiver may be estimated by computing the carrier power and the interference power generated by all mobile terminals and hubs. The C/I is then converted to an $E_B/(N_0+I)$ value and the PER is evaluated using eqns. 2 and 3.

HIPERLAN system simulation: The Monte Carlo simulation used in [3] was modified to provide a clock-tick driven simulation of a HIPERLAN (type 1) network of 20 cells of a 50m radius (to cell vertices) in a square cell arrangement, and 200 class A (10dBm transmit power) mobile HIPERLAN terminals, 10 per cell.

Mobile terminals were randomly placed with a uniform area distribution in each cell, and packets were transmitted from terminals in a random sequence. Cells were clock-tick synchronised. Per-cell link utilisations between 50 and 100% were modelled using a Poisson packet arrival process. More accurate traffic models for different types of data communication sessions are still being developed [4].

The propagation model assumed was similar to that used in the original development of HIPERLAN [5]. A dual slope path loss model was used with an initial path loss exponent $\gamma_1 = 2.0$–10m and a second exponent γ_2 between 2.5 and 3.5m at distances > 10m. In addition, it was assumed that the channel exhibited Rician fading with a Rice factor $K = 10$. In all other respects it was assumed that the channel was equalised.

The PER was averaged over the total simulation of one million packet transmissions to provide a PER estimate for both the uplink and downlink. The downlink PER results tended to be very similar to the uplink results and the simulation results in this Letter refer to the uplink.

In the simulation, the CCA was invoked whenever the short term PER at a hub rose above 10^{-3}. In a square cell layout, a co-channel terminal at the centre of an adjacent cell would generate –86.5dBm of interference with $\gamma_2 = 3.5$. Hence, it is possible that the CCA scheme could flag this channel as being ‘free’ with the CCAT = –75dBm, despite this interference being sufficient to cause a large probability of packet errors.

HIPERLAN system performance: Simulations were performed to estimate the PER of the 20 cell, 200 user network, as the CCAT was varied from –95 to –75dBm for different link utilisations and path loss exponents γ_2.

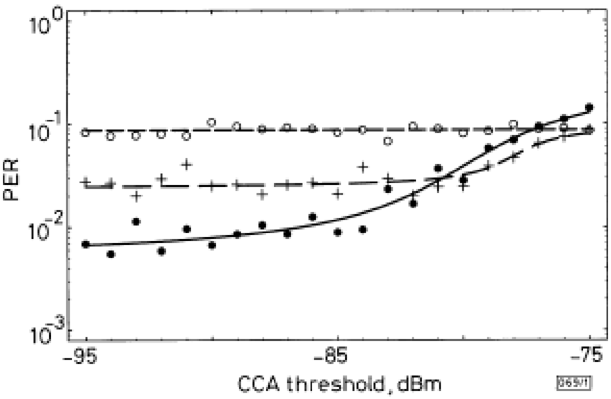

Fig. 1 *PER against CCAT and path loss exponent*

○ $\gamma_2 = 2.5$
+ $\gamma_2 = 3.0$
● $\gamma_2 = 3.5$

First, the PER was estimated as the path loss exponent γ_2 was varied from 2.5 to 3.5 at 100% link utilisation. The results are shown in Fig. 1. It can be seen that with the CCAT at –75dBm, the PER is close to 10^{-1} at all path loss exponents. As the CCAT is reduced, the PER improves to ~7×10^{-3} at $\gamma_2 = 3.5$, 2×10^{-2} at $\gamma_2 = 3.0$, but does not improve at all at $\gamma_2 = 2.5$.

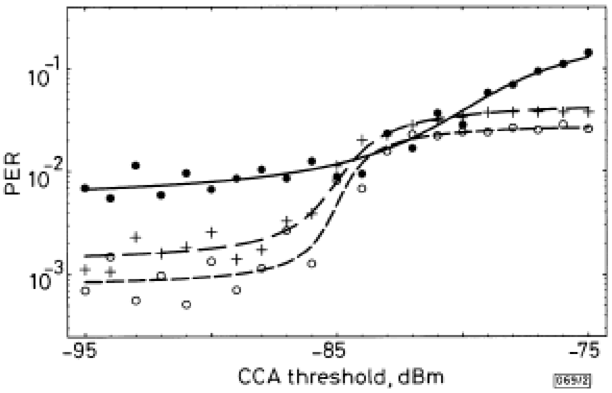

Fig. 2 *PER against CCAT and link utilisation*

○ 50%
+ 68%
● 100%

When the CCAT is too high, even an adjacent cell co-channel interferer generates interference below the CCAT. Under these conditions, the net effect of the CCA algorithm is to choose the first channel measured (as it will always satisfy the CCAT) and channel assignment essentially becomes random. The probability of adjacent cell co-channel interference becomes high and results in a poor PER.

When the CCAT approaches the noise floor of the receiver (–95dBm), the net effect of the CCA algorithm is for the channel with the lowest amount of measured interference to always be chosen. This results in an improved PER performance under moderate path loss conditions. However, when the path loss exponent is small, the amount of interference from other terminals is very high and always exceeds the CCAT, returning HIPERLAN operation to essentially random channel assignment. The CCAT therefore provides no differentiation between channels at low path loss exponents and varying it has no effect.

Next, the PER was estimated while the link utilisation was varied from 50 to 100% with $\gamma_2 = 3.5$. The results are shown in Fig. 2. Again we see that the PER is asymptotic at both ends of the CCAT scale. At a high CCAT, channel assignment is effectively random. At a low CCAT, the channel with the lowest amount of measured interference is always chosen. At both extremes, varying the CCAT no longer affects the PER.

As expected, the overall PER improves as link utilisation decreases to < 100%. The PER improvement resulting from lowering the CCAT appears to increase as link utilisation decreases i.e. the CCAT becomes an increasingly better discriminator.

Conclusion: Channel assignment RSSI thresholds are useful for preventing ‘channel hoarding’ in conventional cellular systems with large numbers of channels. HIPERLAN, however, has only five channels and the PER penalty for a poor channel assignment is very large.

The results in this Letter suggest that the best RSSI-based HIPERLAN channel assignment strategy is to always choose the channel with the lowest amount of measured interference, rather than the first channel measured below the CCAT.

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