IEEE P802.11
Wireless LANs

CCA Threshold Definition to Guarantee Service Quality in Multicell Environment

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Abstract

In a multicell environment, a co-channel interference is the most important factor which affects a system service quality. In IEEE802.11 based systems, CCA (Clear Channel Assessment) scheme has capability to detect the co-channel interference. Therefore the level of the CCA threshold is very important to detect intolerable interference to guarantee the service quality. In this document, we propose a method of definition of the CCA threshold in the multicell environment.

1. Effects of Co-Channel Interference in Multicell Environment

To realize a large scale wireless LAN system, it is necessary to cover all of its service area with multiple cells. As a technology for the multicell environment, it is popular to reuse the same channel among the cells. However, due to the channel reuse, co-channel interference is caused among the cells where the same channel is used. As a result, the interference increases packet errors. A parameter named CCI (Co-Channel Interference) immunity is given as a value of CIR (Carrier to co-channel Interference Ratio) where the packet error rate is less than 10% in TGa comparison matrix[Doc. 98/157r3].

To guarantee some quality of service, such as packet error rate of less than 10%, in the multicell environment, it is necessary to satisfy the CCI immunity over the whole cell. Therefore it is important to detect intolerable co-channel interference by the CCA scheme.

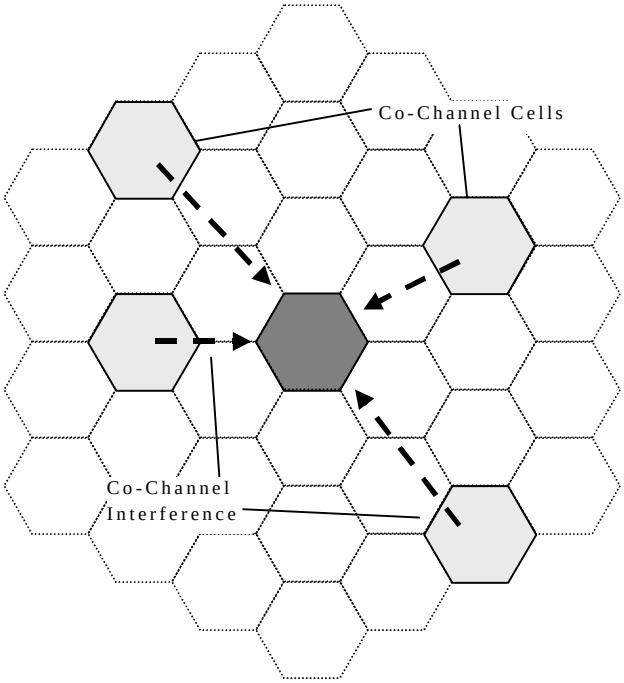

Figure1: Co-Channel Interference in Multicell Environment

2. Definition of CCA Threshold

2.1. Signal Levels

Figure 2 shows relations among signal levels and the cell radius.

In order for a transmitter or a receiver to detect the carrier signal from other equipment, the carrier level must be higher than its minimal carrier sense level. Hence, the minimal carrier sense level determines a radius

of a carrier detectable area. We define a covered area as an area wherever a receiver can receive signals transmitted any other equipment in the area with a higher level than its minimal sensitivity. The cell must be smaller than both the carrier detectable and the covered areas. Assuming that the receiver locates at the center of the cell, its minimum carrier level is given as a received signal level of a carrier transmitted from a transmitter locating at the cell edge.

We define an intolerable interference as an interference whose level cannot satisfy the CCI immunity compared with the minimum carrier level. The ratio of the minimum carrier level and the minimum level of the intolerable interference is equal to the CCI immunity. The minimum intolerable interference level determines a radius of an area where the intolerable interference can be originated. The interference from the area cannot satisfy the CCI immunity for the receiver at the center of the cell when the carrier signal comes from the cell edge.

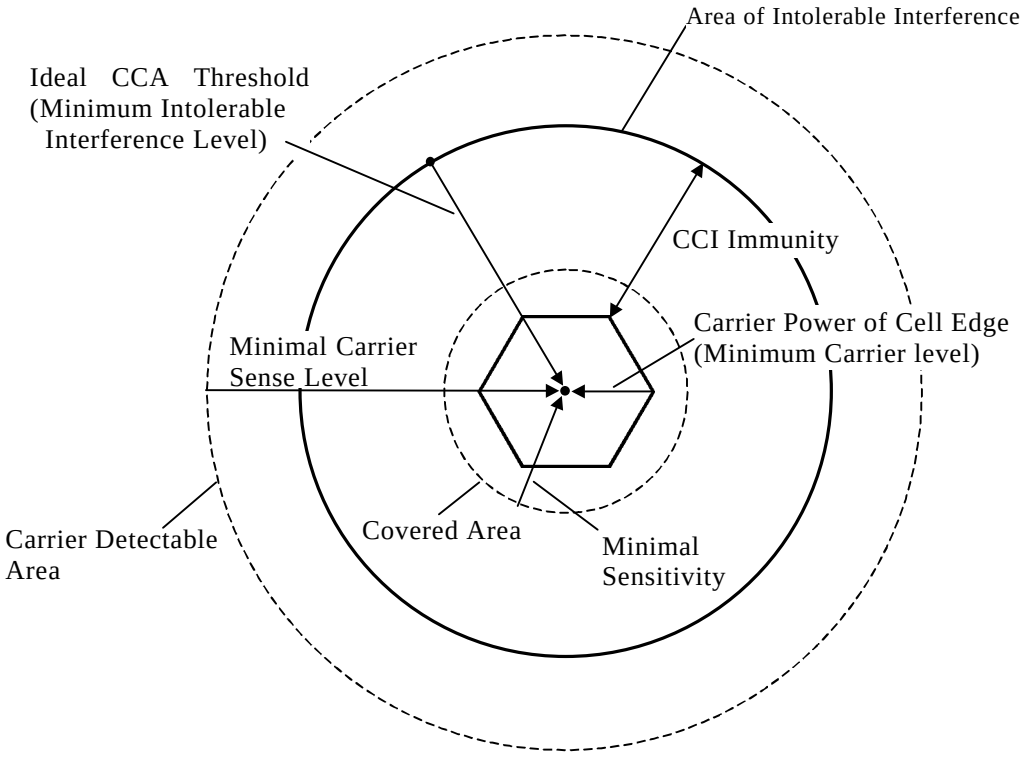

Figure2: Relations among Signal Levels

2.2. Ideal CCA threshold

By introducing P_{cell_edge} as the carrier power of the cell edge, the minimum intolerable interference level is derived from P_{cell_edge} and $CCI_{immunity}$ as follows,

$$P_{i\_CCI} = P_{cell\_edge} - CCI_{immunity}. \quad \text{(dB)} \qquad (1)$$

In order to guarantee the CCI immunity all over the cell, it is required for a transmitter to detect the minimum intolerable interference by the CCA scheme. Hence, we define P_{i_CCI} as an ideal CCA threshold. Figure 3 illustrates relationship among P_{cell_edge}, $CCI_{immunity}$ and P_{i_CCI} levels.

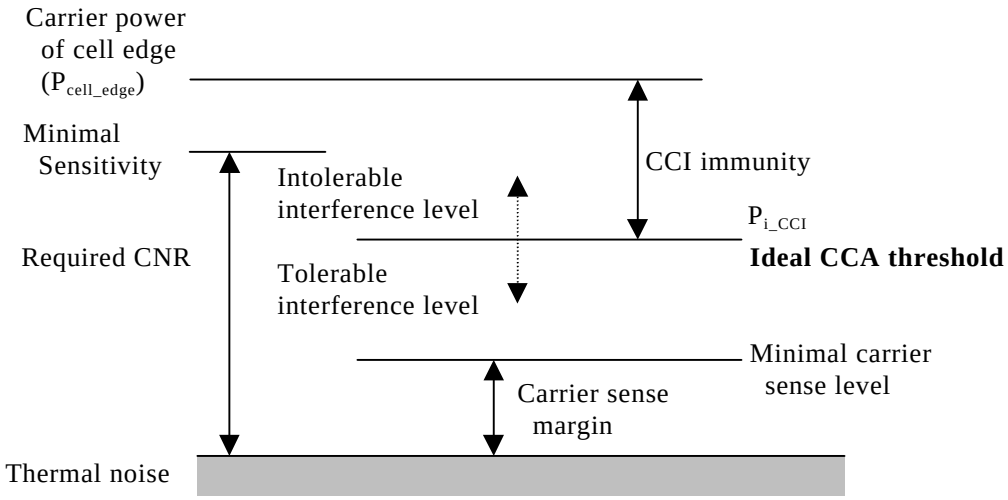

Figure 3: Relationship of the levels

In the relationship, P_{cell_edge} may not be lower than the minimal sensitivity. Therefore, in order to realize the maximum cell radius, P_{cell_edge} is equal to the minimal sensitivity. In this case, the ideal CCA threshold is derived by the minimal sensitivity and the CCI immunity as shown in Fig. 4.

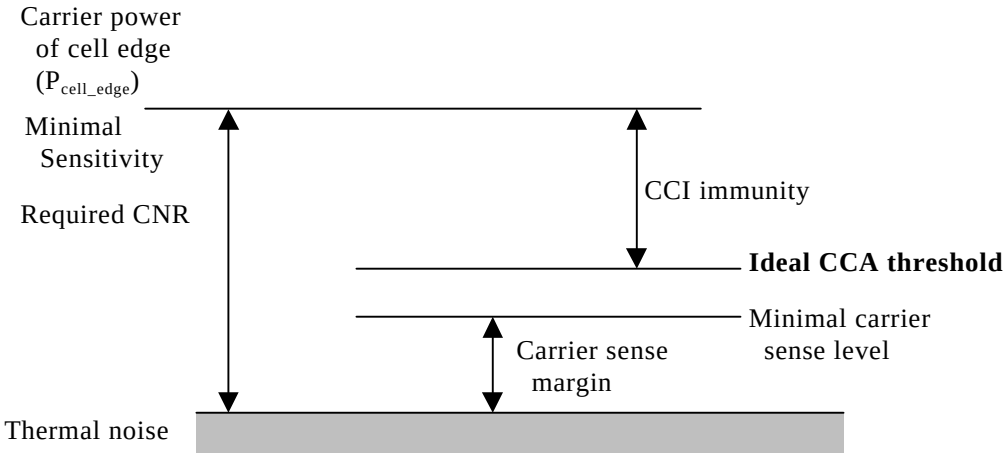

Figure 4: Ideal CCA threshold with the maximum cell radius

2.3. Practical CCA threshold

When the required CNR is smaller than the sum of the carrier sense margin and the CCI immunity, the ideal CCA threshold for the maximum cell radius becomes lower than the minimal carrier sense level as shown in Fig. 5.

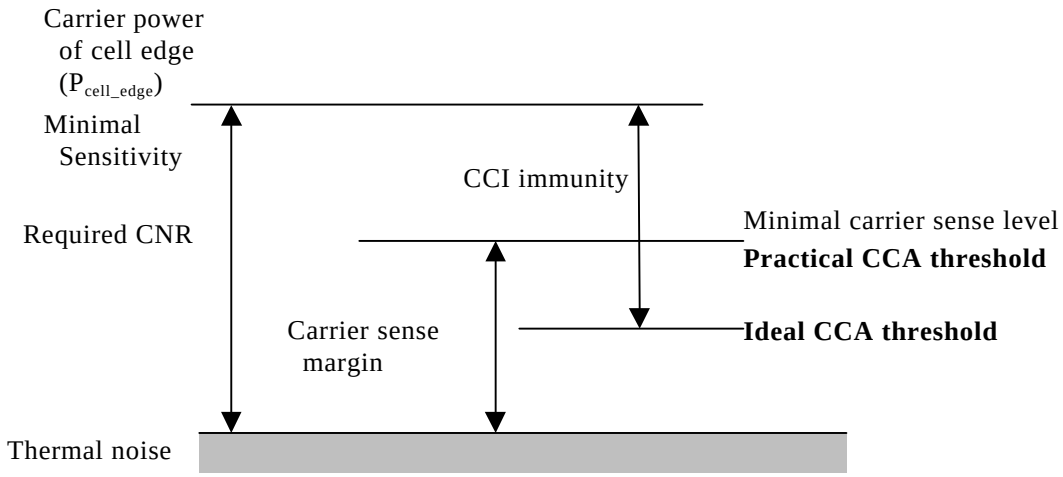

Figure 5: Ideal CCA threshold lower than Minimal carrier sense level

In this case, a practical CCA threshold should be set to the same level as the minimal carrier sense level, because we cannot set the practical CCA threshold lower than the minimal carrier sense level. Therefore, the CCI immunity cannot be satisfied when the carrier signal comes from a transmitter around the cell edge.

To guarantee the quality of service over the whole cell in the situation described in Figure 5, we need to take a lower limit of P_{cell_edge} into consideration. We define the lower limit as Limited P_{cell_edge} as follows,

$$\text{Limited } P_{cell\_edge} = \text{Practical CCA threshold} + \text{CCI immunity.} \quad (2)$$

The Limited P_{cell_edge} can be determined as shown in Fig. 6.

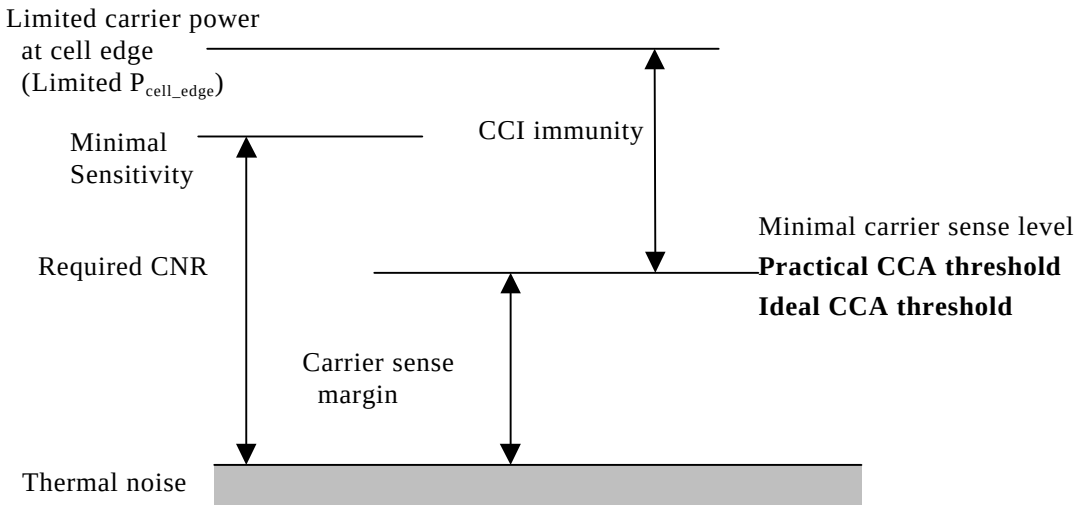

Figure 6:Limited P_{cell_edge}

The practical CCA threshold are expressed as follows, when

Minimal sensitivity ≥ Minimal carrier sense level + CCI immunity, (3)

the practical CCA threshold is given by

Practical CCA threshold = Minimal sensitivity – CCI immunity, (4)

and when

Minimal sensitivity < Minimal carrier sense level + CCI immunity, (5)

the practical CCA threshold is given by

Practical CCA threshold = Minimal carrier sense level. (6)

By defining a function Max(A,B) which gives a larger value of A and B, the practical CCA threshold is given by

Practical CCA threshold =Max(Minimal carrier sense level, Minimal sensitivity – CCI immunity) (7)

As shown above, the CCI immunity, the minimal carrier sense level and the minimal sensitivity are necessary to define the practical CCA threshold.

3. Example of CCA thresholds Definition

Figure 7 shows an example of the ideal CCA threshold based on the parameters in Table 1. We refer the parameters from Doc 98/167. There is no definition of the minimal carrier sense level in the document, therefore we assume the minimal carrier sense level is equal to the CCA threshold in the document.

Parameters	value
Minimal Sensitivity	–77 dBm
CCI immunity	9 dB
Minimal carrier sense level	–82 dBm

Table 1: Parameter for the ideal CCA threshold in Fig. 7.

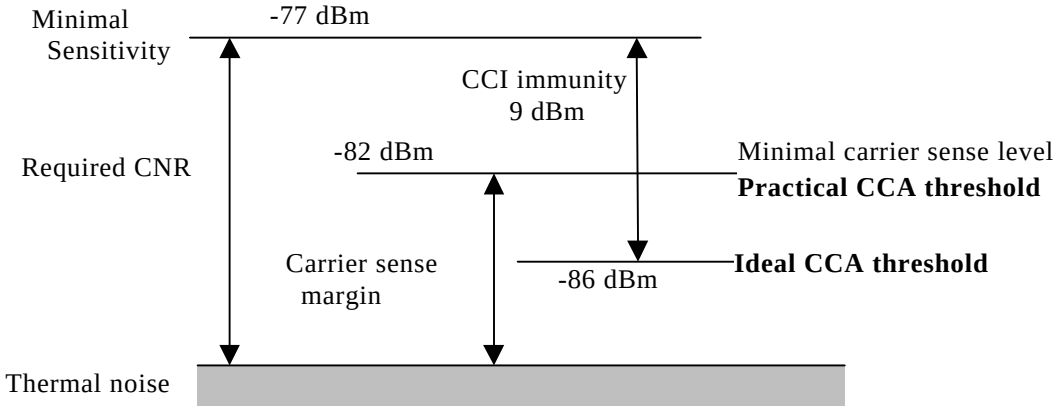

Figure 7: Example of Ideal CCA threshold

In this case, because the ideal CCA threshold is lower than the minimal carrier sense level, the practical CCA threshold should be set to –82dBm. Therefore, to guarantee the service quality over the whole cell, the limited P_{cell_edge} needs to be –73dBm as shown in Fig.8.

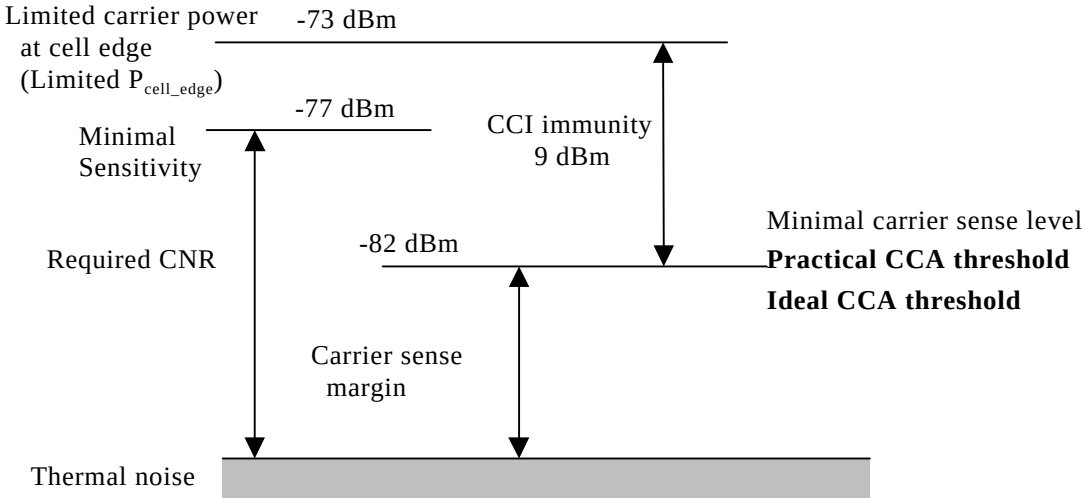

Figure 8: Example of Limited P_{cell_edge}

Regarding to Fig. 8, a new table is expressed as Table 2.
By designing the large scale wireless LAN system with the parameters shown in Table 2, the service quality can be guaranteed over the whole cell in the multicell environment.

Parameters	value
Minimal Sensitivity	–77 dBm
CCI immunity	9 dB
Minimal carrier sense level	–82 dBm
Practical CCA threshold *1	–82 dBm
Limited P_{cell_edge} *2	–73 dBm

*1: from Equ.(7). *2: from Equ. (2).

Table 2: Proposed Practical CCA threshold and Limited P_{cell_edge}.