Interference analysis study for coexistence between C-V2X and Wi-Fi 6E in the 6GHz band

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Abstract—**Interference between C-V2X(Cellular Vehicle to Everything) usage and Wi-Fi 6E can occur in the 5.9GHz band designated for ITS(Intelligent Transportation System) purposes, so interference analysis between the vehicle and the AP(Access Point) is performed to protect C-V2X from interference to derive the distance of each RSRP(Reference Signal Received Power).**

Keywords—C-V2X, Wi-Fi 6E, Interference Analysis, AFC

I. Introduction

Since the existing AFC(Automated Frequency Control) is an operating system for frequency coexistence between Wi-Fi 6E in the 6GHz band and existing inbound users, it is not considering protection for C-V2X using the 5.9GHz band, so it is necessary to come up with an alternative to the protection of C-V2X. In order for the use of Wi-Fi 6E in the 6GHz sub-band(5,925MHz to 6,425MHz) to coexist without causing interference with the use of C-V2X in the 5.9GHz band, it is necessary to calculate the interference probability and protection distance through interference analysis between Wi-Fi 6E and C-V2X[1][2][3][4].
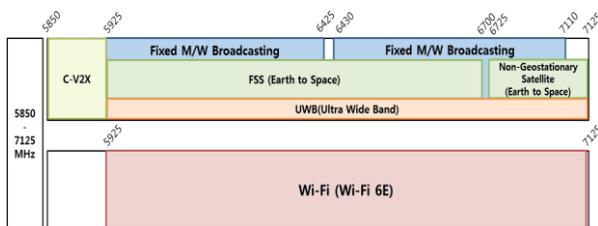

Fig. 1. 6GHz frequency allocation band and adhacent band status

II. Interference Anlysis

When a new radio station requests a radio station permit within the radio environment where existing radio stations exist, to obtain approval, the operation of a new radio station is permitted if interference is below the standard for mutual coexistence through radio interference analysis between existing and new radio stations. If such interference can be predicted, the transmission power or frequency band of the radio station will be adjusted to reduce interference and enable more efficient frequency use. Methods commonly used as interference analysis methods between wireless systems can be largely divided into interference analysis using the MCL(Minimum Coupling Loss) method and MC(Monte Carlo) method[5].

A. dRSS(desired Received Signal Strength)

dRSS, which is a Wt(Wanted transmitter) signal received from Vr(Victim receiver), may be expressed as Equation (1).

$$dRSS = P_{Wt} + G_{Wt \to Vr} + G_{Vr \to Wt} - PL \qquad (1)$$

P_{Wt} is the maximum transmission power of the transmitter, $G_{Wt \to Vr}$ is the transmitter antenna gain, $G_{Vr \to Wt}$ is the receiver antenna gain, and PL is the path loss from the transmitter to the receiver

B. iRSS(interference Received Signal Strength)

The iRSS, which is an It(Interfering transmitter) signal received from Vr, may be expressed as Equation (2).

$$iRSS = P_{It} + G_{It \to Vr} + G_{Vr \to It} - PL \qquad (2)$$

P is the maximum interference transmission power, $G_{It \to Vr}$ is the interference antenna gain, $G_{Vr \to It}$ is the receiver antenna gain, and PL is the path loss from the interference to the receiver.

C. Interference Probability

In this paper, interference was determined using the C/(N+1) (Carrier to Noise plus interference) technique. Interference analysis of the C/(N+I) technique includes noise in the existing C/I (Carrier to Interference) technique, and the interference analysis procedure is the same as the C/I technique that determines interference by calculating theratio of desired signal and interference signal based on the C/I value provided by the equipment manufacturer. Whetheror not to interfere is determined through Equation (3) and (4) below.

$$C/(N + I) > [C/(N + I)]_{threshold} \qquad (3)$$

$$C/(N + I) < [C/(N + I)]_{threshold} \qquad (4)$$

Interference does not exist in the case of Equation (3), and interference occurs in the case of Equation (4). The interference probability refers to the probability that the

throughput required by the system is not satisfied when the iRSS received by the Vr is relatively larger than the dRSS. In this paper, assuming that dRSS is always received above sensitivity, Compare the interference power iRSS due interference of Unwanted Emission and Blocking. After that, the probability of satisfying Equation (4) is calculated. Equation (5) shows the process of calculating the probability of interference.

$$P = P\left\{\frac{dRSS}{iRSS} < \frac{C}{I+N} \mid dRSS > Sensitivity\right\} \qquad (5)$$

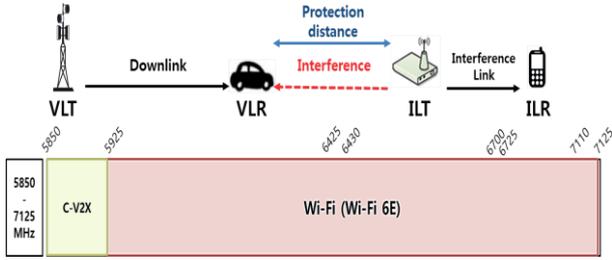### III. SIMULATION

A. Interference Analysis Scenario

Fig. 2. Interference Scenario between Wi-Fi 6E and C-V2X

Victim link is a RSU(Road Side Unit) and OBU(On-Board Unit), Interfering link is a Wi-Fi 6E AP and Client. Wi-Fi 6E AP and OBU exist in urban areas, and interference was analyzed according to the separation distance between Wi-Fi 6E AP and OBU present in nearby bands in Downlink(RSU to OBU) situations. Indoor use of the next generation Wi-Fi 6E is less than 250mW, which can be used regardless of interference, so indoor interference analysis was not performed. When the Wi-Fi 6E AP was 30dB, the maximum output , a protection separation distance satisfying the interference probability of 5% or less was calculated. The WINNER II radio wave loss model, which is most commonly used in urban areas of urban and suburban, where transceivers are distributed up to 2km, was used. The Wi-Fi 6E AP parameters set as an interference in this paper are shown in Table 1 below[6][7][8].

TABLE I. WI-FI 6E PARAMETERS

Parameters	Unit
Center Frequency	6,005MHz
Transmitter Power	30dbm
Bandwidth	160MHz
Tx Antenna Type	Omni directional
Tx Antenna Gain	2dBi
Tx Antenna Height	1.5m

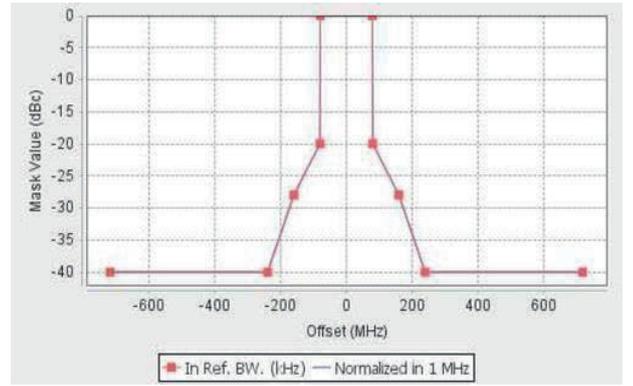The emission mask of the Wi-Fi 6E AP is shown in Figure 3.

Fig. 3. Wi-Fi 6E Emission Mask

The parameters of C-V2X set as the transmitter and receiver of the Victim link are shown in Table 2[9][10][11].

TABLE II. C-V2X PARAMETERS

Parameters	Unit
Center Frequency	5,910MHz
Transmitter Power	23dbm
Bandwidth	10MHz
Rx Antenna Type	Omni directional
Rx Antenna Gain	1dBi
Rx Antenna Height	1m
Noise floor	103dBm
Sensitivity	-90.4dBm
Max distance	107m
C/(I+N)	-1Db

B. Interference Analysis Simulationi Result

C-V2X divided each road by 20m×20m of grid and set it to be distributed within the grid, and Wi-Fi 6E AP was set to exist between min distance around the set grid and max distance. In the above situation, 20,000 events were randomly generated using the Monte-Carlo technique to calculate a protection distance that satisfies within 5% of the interference probability. The corresponding figure is shown in Figure 4.
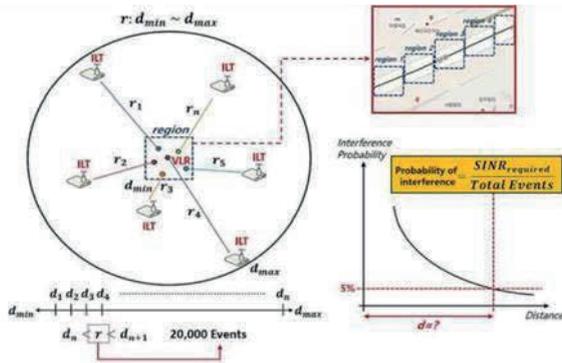
Fig. 4. Interference analysis scenatino between C-V2X and Wi-Fi 6E

When the value of SINR required as a result of interference analysis was -1dB, The protection separation distance according to the RSRP value of the C-V2X and OBU was calculated. The results showed that a minimum protective separation distance of 255m when RSRP is -60dBm, 310m when RSRP is -70dBm, 380m when RSRP is -80dBm, and 605m when RSRP is -90dBm, respectively. The result is shown in the graph of Figure 5 and 6.
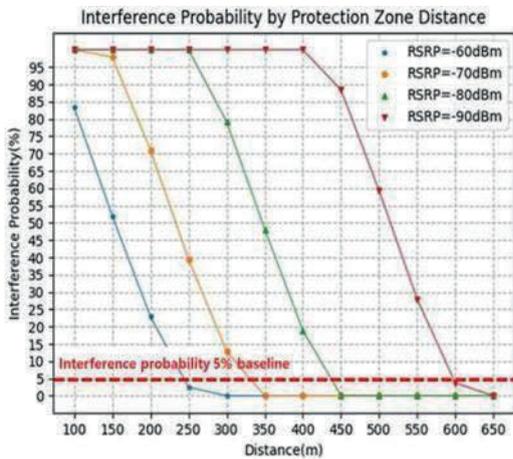
Protection distance	100	150	200	250	300	350	400	450	500	550	600	650
RSRP=>-60dBm	83.4	52	22.9	2.5	0	0	0	0	0	0	0	0
RSRP=>-70dBm	100	97.9	71	39.5	12.8	0	0	0	0	0	0	0
RSRP=>-80dBm	100	100	100	100	79.2	48.1	18.8	0.1	0	0	0	0
RSRP=>-90dBm	100	100	100	100	100	100	100	88.4	59.2	27.8	3.7	0

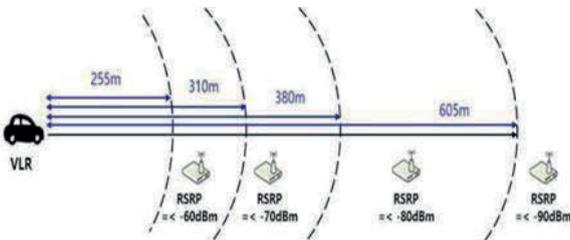Fig. 5. Interference analysis results between C-V2X and Wi-Fi 6E

Fig. 6. Protection separation distance for each RSRP of the 5G device

IV. Conclusion

In this paper, for the mutual coexistence of C-V2X in the 5.9GHz band and Wi-Fi 6E in the 6GHz band, a study was conducted to prepare specific interference protection standards considering the potential interference of Wi-Fi 6E on C-V2X. As a result of the interference analysis between C-V2X and Wi-Fi 6E, when the RSRP of C-V2X is less than -60dBm, a minimum protective separation distance of 255m is required, and when the RSRP is less than -70dBm, a minimum protective separation distance of 310m, -80dBm When it is smaller than the protective separation distance of at least 380m, and when it is smaller than -90dBm, the protective separation distance of at least 605m is suggested.

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