DTV에 대한 WiFi의 간섭영향 분석

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Analysis on Interference Impact of WiFi on DTV

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요 약

아날로그 텔레비전에서 디지털 텔레비전으로 전환할 때 TVWSs (TV White Spaces)가 발생된다. TVWSs에는 일부 무선 통신 시스템이 사용가능하며, 예를 들면 면허가 필요하지 않는 WiFi (Wireless Fidelity)가 있다. 또한, TVWSs는 VHF와 UHF의 사이에 주파수로써, 현재 WiFi가 사용하고 있는 2.4 GHz 및 5 GHz주파수와 비교할 때 TVWSs는 WiFi보다 더 큰 적용범위를 제공하고 건물에 대한 더 높은 침투력을 갖고 있다. 그러므로 본 연구는 WiFi가 TVWSs 주파수 구간에서 사용가능하다고 가정한 후, DTV에 대한 WiFi의 간섭영향을 분석하였다. SEAMCAT (Spectrum Engineering Advanced Monte-Carlo Analysis Tool)을 이용하여 DTV 수신기가 받는 간섭확률을 분석하였다. 분석결과 20개의 WiFi 사용자가 동시에 최대 전송전력으로 작동하였고 22 MHz 가드 밴드가 요구되었으며, WiFi 사용자와 DTV 수신기 간의 보호거리가 6 km이상일 때 DTV 수신기의 5%이하 간섭확률 성능을 만족할 수 있는 것으로 나타났다.

Key Words : TVWS, DTV, WiFi, interference probability, guard band, protection distance

ABSTRACT

TV White Spaces (TVWS) are freed up after transition from analog television to Digital Television (DTV). Some wireless communications are allowable to operate in TVWSs, such unlicensed Wireless Fidelity (WiFi). Because TVWSs are located in the VHF and UHF bands, TVWSs can provide significantly better coverage and wall penetration inside buildings and other structures than the 2.4 GHz and 5 GHz WiFi frequencies currently in use. Therefore, this paper assumes that WiFi will be deployed in TVWSs. However, the interference impact of WiFi on DTV has to be taken into account. The interference probability in DTV receiver was evaluated by using Spectrum Engineering Advanced Monte-Carlo Analysis Tool (SEAMCAT). As a result,when 20 WiFi UEs are simultaneously operating at the maximum transmit power of 23 dBm and the guard band is 22 MHz, the protection distance should be at least 6 km to meet the interference probability of 5% in DTV receiver.

Ⅰ. Introduction

The Federal Communications Commission's (FCC) desires to make more Very High Frequency (VHF) and Ultra High Frequency (UHF) bandwidth available for wireless communications. Pursuant to this, the FCC adopted rules to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used by licensed services - this unused TV spectrum is often termed as TV White Spaces (TVWS), more TVWSs are freed up by the FCC

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논문번호 : KICS2011-06-260, 접수일자 : 2011년 6월 19일, 최종논문접수일자 : 2011년 10월 10일

when the U.S. transits from analog television to Digital Television (DTV). TVWSs can provide significantly better coverage and wall penetration inside buildings and other structures than the 2.4GHz and 5GHz Wireless Fidelity (WiFi) frequencies currently in use[1]. On the basis of above condition, this paper assumes that WiFi will be deployed in TVWSs. Therefore, the interference impact of WiFi on DTV has to be taken into account. Spectrum Engineering Advanced Monte-Carlo Analysis Tool (SEAMCAT) is chosen as interference analysis tool to evaluate the performance of DTV receiver impacted by WiFi.

Ⅱ. System Descriptions

Wi-Fi is a term for certain types of WLAN that use specifications in the 802.11 family. WiFi typically extends an existing wired local area network. it is built by attaching a device called the access point (AP) to the edge of the wired network. Clients communicate with the AP using a wireless network adapter similar in function to a traditional Ethernet adapter. WiFi has gained acceptance in many businesses, agencies, schools, and homes as an alternative to a wired LAN. Many airports, hotels, and fast-food facilities offer public access to Wi-Fi networks. Main parameters of WiFi are summarized in Table 1[2-3].

Emission limit for WiFi is shown in Table 2.

Digital Television (DTV) is an advanced broadcasting technology that transmits audio and video by digital signals. In contrast to the analog signals used by analog TV, DTV has several advantages over analog TV, such as requiring less bandwidth, providing high-definition television service, providing multimedia or interactivity, etc.[4]. Therefore, many countries are replacing over-the-air broadcast analog television with digital television to allow other uses of the radio spectrum formerly used for analog TV broadcast. DTV adopts US DTV standard (ATSC) in this paper, main relevant characteristics of DTV are summarized in Table 3 [5].

DTV blocking response is defined in Table 4 by referring to DVB-T blocking response as the opposite of the protection ratio for DVB-T signal

표 1. WiFi의 주요 파라미터
Table 1. Main parameters of WiFi

Parameter	Value
Frequency	567MHz
Reception Bandwidth	22,000 kHz
Receiver Sensitivity	-76 dBm
Noise Floor	-90.41 dB
Antenna Height	Rx 1.5/Tx 2.5 m
Antenna Azimuth	0~360 Degree
Antenna Peak Gain	6 dBi
Antenna Pattern	Omni-directional
Output Power	23 dBm

표 2. WiFi의 스펙트럼 방사제한
Table 2. WiFi emission limit

Frequency offset from center frequency[MHz]	Attenuation [dBc]	Reference Bandwidth [kHz]
0~11	0	22000
11~22	-30	22000
22~33	-50	22000

표 3. DTV의 주요 파라미터
Table 3. Characteristics of DTV

Characteristic	Value
Transmit power ERP	4 kW (66 dBm)
Frequency band	587 MHz
Bandwidth	6 MHz
Tx antenna height	100 m
Tx antenna gain	0 dBi
Rx antenna height	10 m
Rx antenna gain	10 dBi
Noise Figure	10 dB
Sensitivity	-83 dBm
C/I	23 dB
Transmit standard	8-VSB
Modulation	FM or QPSK

표 4. DTV 수신기의 블러킹 응답
Table 4. Blocking response for DTV receiver

△Frequency (MHz)	-15	-12	-6	-3	0	3	6	12	15
Blocking(dB)	45	38	20	3	-10	3	20	38	45

interfered with by emission of CDMA-1X in ECC REPORT 104[6].

Ⅲ. Methodology and Scenario

3.1 Methodology

A new statistical simulation model has been developed based on the Monte-Carlo method by the European Conference of Postal and Telecommunications Administrations (CEPT), named Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT). Figure 3 illustrates the principle of calculating the interference probability in victim receiver in SEAMCAT. When interference is introduced, the interference adds to the noise floor. The difference between desired received signal strength(dRSS) and the interfering received signal strength (iRSS) is measured in dB, which is defined as the Signal to Interference ratio(C/I_{trial}). This ratio must be more than the required C/I threshold (C/I_{target}) if interference is to be avoided. The Monte Carlo simulation methodology is used to check for this condition and records whether or not interference is occurring[7].

SEAMCAT calculates the probability of interference (P_I) of the victim receiver as follows:

$$P_I = 1 - P_{NI} \qquad (1)$$

Where P_I is the probability of interference in the victim receiver. P_{NI} is the probability of non interference (NI) of in victim receiver. When a C/I criterion is considered, P_{NI} is defined as:

$$P_{NI} = P\left(\frac{dRSS}{iRSS} > \frac{C}{I} \middle| dRSS > \text{Sensitivity}\right) \qquad (2)$$

By definition of P(A|B)=P(A∩B)/P(B), P_{NI} becomes:

$$P_{NI} = \frac{P\left(\frac{dRSS}{iRSS} > \frac{C}{I}, dRSS > \text{Sensitivity}\right)}{P(dRSS > \text{Sensitivity})} \qquad (3)$$

with $iRSS = \sum_{j=1}^{P} iRSS_j$ where P is the number of interferers (i.e. active interferer transmitters).

3.2 Interference Scenario

In DTV bands, channel 34(CH34) is assumed to allocate to DTV and channel33 (CH33), channel32 (CH32), channel 31 (CH31) and upper 4 MHz of channel 30 (CH30) are assumed to allocate to WiFi. Figure 2 illustrates an assumption of frequency allocation for WiFi and DTV in DTV bands.

Figure 3 illustrates scenario of interference impact of multiple WiFi user equipments (UEs) on DTV receiver. A typical Wi-Fi access point can support some 15 to 20 users [8], therefore 20 UEs are assumed to be deployed within one AP. Only interference of UEs on DTV receiver is taken into account. The interference probability of 5 % is assumed to meet the performance requirement of

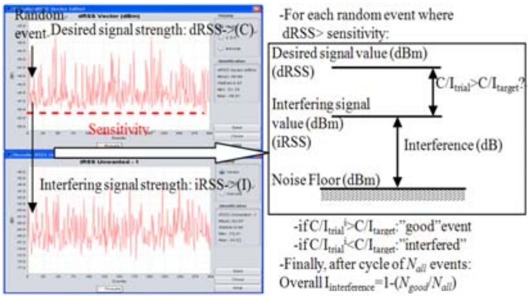

그림 1. 간섭확률 산출 설명
Fig. 1. Illustrative summary of the interference criteria computation

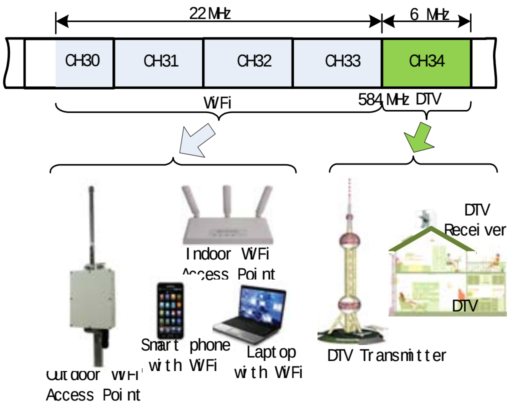

그림 2. DTV 주파수대에서 주파수를 WiFi과 DTV로 분배하는 가설
Fig.2. Assumption of frequency allocation for WiFi and DTV in DTV bands

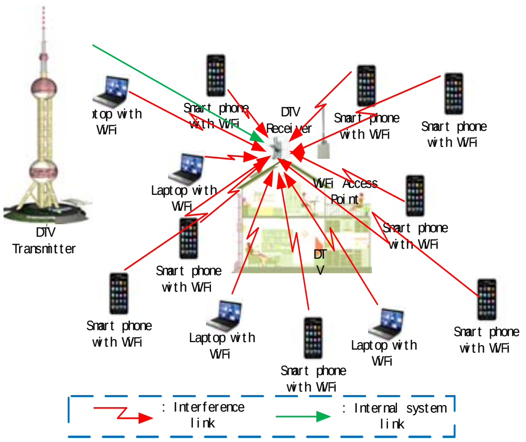

그림 3. 다수의 WiFi 사용자와 DTV에 대한 간섭 시나리오
Fig. 3. Scenario of WiFi interfering with DTV

DTV receiver. And then, the different required protection distance between WiFi UEs and DTV receiver, the different reqired guard band, the maximum allowable transmit power of WiFi is evaluated, respectively.

Ⅳ. Simulation and results

According to the scenario of WiFi interfering with DTV and parameters of WiFi and DTV, main setups in SEAMCAT are summarized as following:

General:
Snapshot: 100

Victim: DTV.
Fvictim= 587 MHz.
Bandwidth=6 MHz.
Sensitivity=-83 dBm.
Considering the worse the case, Desired received signal strength (dRss) in DTV of -82 dBm is assumed which is close to sensitivity of -83 dBm.
C/I= 23 dB.
Blocking response of DTV receiver in Table 4 is used
Propagation model: Extended Hata, Urban

Interferer: WiFi.
Finterferer=573MHz/562MHz/551MHz.
UE Transmit power=23 dBm.
Emission mask of UE is set up according to Table 2.
Interfering system link: Extended Hata.
Interference link (WiFi UE to DTV receiver): Extended Hata, Urban.

The evaluation of the interference probability from WiFi UE into DTV receiver is implemented in SEAMCAT. One snapshot of simulation status is illustrated in Figure 4.

The interference probability based on the different guard band and the different protection distance between WiFi UEs and DTV receiver is illustrated in Figure 5.

Under condition of meeting the maximum allowable transmit power of WiFi UE of 23 dBm and the interference probability of 5 %, Figure 6 shows that when there is no the guard band between WiFi and DTV, the interference situation from WiFi

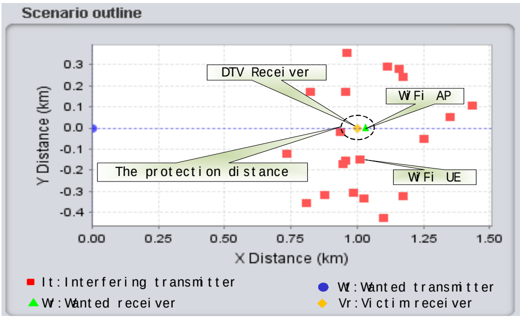

그림 4. SEAMCAT에서 나타난 다수의 WiFi 사용자와 DTV에 대한 간섭 시나리오
Fig. 4. Scenario of WiFi UE interfering with DTV receiver in SEACMAT

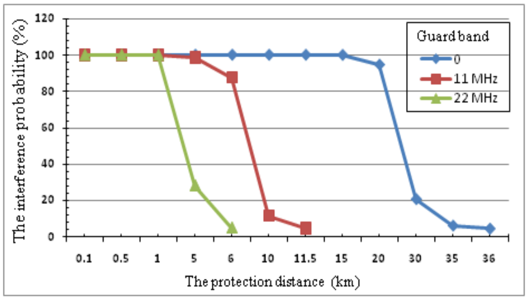

그림 5. 간섭확률과 보호거리와의 관계
Fig. 5. The relationship between the interference probability and the protection distance

UE into DTV receiver is the worst case. The protection distance should be more than 36 km. When the guard band is 22 MHz, the protection distance should be at least 6 km.

Based on the different required protection distance and the different required guard band, the corresponding maximum allowable transmit power of WiFi UE can be figure out to meet the interference probability of 5 %, which is illustrated in Figure 6.

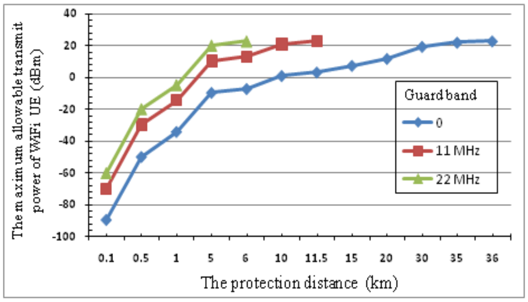

그림 6. WiFi 사용자의 최대 허용 전송전력과 보호거리
Fig. 6. The relationship between the maximum allowable transmit power of WiFi UE and the protection distance

Ⅳ. Conclusions

WiFi is assumed to be deployed in TVWSs because TVWSs are able to provide significantly better coverage and wall penetration inside buildings and other structures than the 2.4 GHz and 5 GHz WiFi frequencies. Therefore, the inerference impact of WiFi on DTV receiver was analyzed by using SEAMCAT. As a result , when 20 WiFi UEs are simultaneously operating at the maximum transmit power of 23 dBm and the guard band is 22 MHz, the protection distance should be at least 6 km to meet the interference probability of 5%. Aslo, according the different required protection distance and the diffenet guard band, the corresponding maximum allowable transimt poower of WiFi UE can be figure out to meet the interference probability of 5%. The results can be used as a reference and guideline for government and related organizations to make frequency plan for deploying WiFi in TVWSs.

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