Technical Analysis for Sharing Frequency Spectrum

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Abstract

A frequency sharing technique is necessary for using the limited frequency resources efficiently. In this paper we study the condition for sharing frequency bands in two cases. One is the case that the frequency band is already allocated to the specific communication. The other is the case of allocating the new frequency bands to communication systems having interference avoiding techniques. For each case we investigate the conditions for sharing frequency bands and the suggestions for that are presented in this paper.

1. INTRODUCTION

Recently how to advance the spectrum policy for the efficient use of frequency resources in the future was studied. In Europe, WAPECS(Wireless Access Platforms for Electronic Communication Services) concept has been discussed, and the technical standards for WAPECS will be derived at EC. In Korea, FACS(Flexible Access Common Spectrum) concept is derived, so any low power devices meeting technical requirements can be used in FACS. It is new paradigm differ from existing spectrum management method in Korea. So, technical requirements meet for technical neutrality without interference are very important factors. In this study, we studied the technical conditions for sharing frequency spectrum without interferences.

Mobile communications was began with a long distance service such as WMAN, and now WPANs providing high or low rate data communication services according to its applications have been investigated. The trends in developing and researching WPANs will promote the appearance of many low power communication systems in the market for the time being. To realize ubiquitous sensor networks, we must use low power transceivers inevitably. Communication systems sharing frequency resources are necessary for using them efficiently. The techniques avoiding the interference between communication systems would be required as a basic function for sharing frequency bands in the future.

There are two methods for allocating frequency bands with considering a means of sharing frequency. One is to reallocate the assigned frequency for the specific communication system to a system having the interference avoiding techniques as a prerequisite condition. The other is to assign new frequency bands for several communication systems. There are many frequency sharing techniques, such as underlay, LBT(Listen before talk), and DAA(Detect and avoid), etc. Underlay technique uses the limited output power for reducing the interference effects to other systems. LBT and DAA can share frequency bands which are not used by other communication systems. Therefore LBT and DAA must be able to monitor the frequency bands in order to check whether other systems are occupying them or not.

The interference between transceivers can not avoid even though interference avoiding techniques are used in the transceivers. Therefore the amount of interference caused by a communication system must be investigated before the system will be serviced and the results of the interference study will be reflected for making the specification of the system for sharing frequency bands. In this paper we study the condition for sharing frequency bands. First the method of sharing the frequency spectrum is studied when the frequency band is already allocated to the specific communication. Second we investigate the sharing condition of frequency bands when new frequency bands are allocated to communication systems having interference avoiding techniques.

2. FREQUENCY SHARING CONDITION

2.1 Sharing the allocated frequency spectrum

In order to minimize the interference between systems, underlay, LBT or DAA technique must be used for sharing the frequency spectrum used by other systems. FH and DS can be used for reducing the interference. The interference between systems can not avoid even though the interference avoiding techniques are used. Therefore the amount of interference caused by a communication system must be studied before the communication system will be used. And the results of the interference study must be considered in making the specification of the system for sharing the frequency band used already by other systems. Even if the changing PHY will be required for sharing the frequency bands, the minimization of changing PHY is recommended.

Interference always exits among communication systems. In case of sharing the allocated frequency spectrum, the interference will be occurred among the previously existing systems and the interference between the new service and the previous one will be generated also. The amount of interference caused by communication systems is different. Therefore we can use the amount of interference generated by the system as a reference for considering whether the frequency bands can be shared or not. If the amount of interference generated by the new service is less than that by the previous system, then the new service can share the frequency bands with the previous one.

2.2 Sharing the new frequency spectrum

ISM bands are non-specified frequency bands. Therefore the frequency bands can be easily accessed by new communication systems. FCC part 15.247 describes FH and DS as the frequency sharing techniques for minimizing interference[3]. In Europe, 860 ~ 868 MHz and 2.4 GHz frequency bands are used for non-specified frequency bands and the frequency bands are specified for the required frequency sharing techniques in detail. ERC-REC 70-03 describes FH, LBT and DS as interference avoiding techniques[4]. When comparing the specification of systems operated in non-specified frequency bands in the united state to that of in Europe, FCC's specification is rough than Europe. If we can make the sharing condition and the technical specification for sharing frequency bands then new systems easily use the frequency bands.

A transmitter should not emit the power if the transmitter does not generate interference. Communication systems using the same interference avoiding technique can easily share frequency bands because the transmitting condition, such as an output power, out-of band emission etc., can be fairly maintained between the systems. However we must find the balancing factor between communication systems using the different interference avoiding technique, for example between LBT and FH, FH and DS, etc. In this paper we consider LBT, FH and DS as an interference voiding technique and we investigate the balancing factor between the interference avoiding techniques.

3. SIMULATION of interference effects

3.1 The method of simulation

We investigate the interference probability caused by a system to decide whether the system can share the frequency bands or not. In analyzing the interference, the system parameters of an interference transmitter, such as an output power, out of band emission, channel bandwidth and duty factor are considered and a receiver bandwidth, intermodulation response attenuation and single tone desensitization of a victim receiver are also included into the analysis. The channel characteristics of the environment surrounding the system and the proper scenarios are needed also. If C/(N+I) of a victim receiver is lower than the required C/(N+I) then the victim receiver can not communicate because of the interference signal. The following is the simplified simulation procedure,

- Select the location of an interference transmitter and

Table 1. Interference probability between systems

		Victim transceiver							
		ZigBee(total)		RFID(total)		Bluetooth(total)		DCP(total)	
		Spur	Block	Spur	Block	Spur	Block	Spur	Block
Interferer	ZigBee	0.084		0.0001		0.02		0.057	
		0.078	0.069	0	0.0001	0.02	0	0.057	0
	RFID	0.051		0.02		0.018		0.046	
		0.016	0.044	0.0035	0.02	0.007	0.014	0.025	0.04
	Bluetooth	0.022		0.025		0.014		0.028	
		0.0092	0.02	0.011	0.022	0.008	0.007	0.02	0.023
	DCP	0.08		0.11		0.04		0.175	
		0.074	0.066	0.063	0.058	0.038	0.008	0.153	0.089

Table 2. System parameters for interference probability simulation

Parameters	RFID[7]		ZigBee[8]	DCP	Bluetooth
	Reader	Tag			
Channel spacing	200 kHz	200 kHz	600 kHz	2 MHz	1 MHz
Transmit power	1W	-10dBm	0 dBm	24 dBm(250mW)	10 dBm
Receiver bandwidth	200 kHz	200 kHz	600 kHz	1.78 MHz	1 MHz
Cell Radius	10 m	10 m	10 m	50 m	0.01 km
Antenna height	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m
Antenna gain	6 dBi	2 dBi	0 dBi	0 dBi	0 dBi
Sensitivity	-70 dBm	-	-92 dBm	-83 dBm	-70 dBm
Receiver protection ratio(C/I)	9 dB	9 dB	15.2 dB	10 dB	11 dB
Receiver blocking	-35dBm @1MHz	-	adjacent : 0 dB alternative:30dB	Ref[5]	Ref[6]
Intermodulation rejection	-	-	-	-	Ref[6]
Spurious emission	-36dBm/ 1MHz	-	-36dBm/1MHz	Ref[5]	Ref[6]

receiver

- Select the location of an victim transmitter and receiver
- Calculate the propagation loss between the interference transmitter and the victim receiver
- Calculate the interference power induced into the victim receiver including the interference power caused by an intermodulation response attenuation, single tone desensitization etc.
- Calculate C/(N+I) of the victim receiver.

3.2 Interference simulation for sharing the allocated frequency spectrum

Table 1 shows the interference simulation results between systems, and the system parameters for the simulation are listed in table 2. When comparing the interference probability between RFID and Bluetooth, Bluetooth's interfering effects are high than that of RFID system itself. Therefore Bluetooth's transmitting parameters must be changed for sharing the frequency bands. And the interfering effects of RFID and DCP to Bluetooth are high than the interference effects of Bluetooth itself, so the transmitting parameters of RFID and DCP must be changed for sharing the frequency bands.

3.3 Interference simulation for sharing the new frequency spectrum

The characteristics of an interfering transceiver and a victim transceiver are listed in Table 3. To find the balancing factor between the different interference avoiding techniques, we must simulate interference effects between systems which use the different frequency sharing techniques. Table 4 gives for system variety, the system bandwidth is listed in table 4. The total bandwidth of 25 MHz is used for simulation. Table 4 shows that the bandwidths of 250 kHz and 500 kHz for FH and 500 kHz for LBT and DS are mainly considered.

The interference simulation of (FH, FH), (FH, LBT), (FH, DS), (LBT, FH), (LBT, LBT), (LBT, DS), (DS, FH), (DS, LBT), (DS, DS) are performed, where A is the interference system and B is the victim system. The simulation condition between (FH, LBT) and (FH, DS) is the same because of the same interfering mechanism. And the simulation condition of (LBT, LBT) equals (LBT, DS) and (DS, LBT) equals (DS, DS).

Fig 1 is the simulation results of (FH, FH) and (LBT, FH). Fig.1 shows that the interference probability of FH1(BW = 250 kHz) is lower than that of FH2(BW = 500 kHz). The interference probability of LBT system having the BW of above 500 kHz is lower than that of FH. In Fig. 1, if we apply a balancing factor to LBT system rather than to FH, LBT applied a balancing factor has a little negative effect for communication because the interference probability of LBT without a balancing factor is not high than FH. However LBT could be more difficult in implementation when the number of systems operated in the same frequency band is increased. And FH system can be easily implemented than LBT system. Therefore the applying the balancing factor to LBT system is reasonable. Fig. 2 show that the simulation results of interference effects of FH, LBT and DS to FH. In Fig. 2 we can see that LBT and DS being applied by a balancing factor have low interference probability than FH. In this case we use the duty factor for balancing the transmitting condition. And the duty factor of 0.9 is used. Fig. 3 shows that the simulation results of interference effects of FH, LBT and DS to LBT. And the bandwidths of 500 kHz and 1 MHz are considered. From Fig. 3 we know that if the victim receiver's bandwidth is the same or larger than the interferer's bandwidth then the interference effects are saturated. In Fig. 3 we use duty factor of 0.9 for LBT and 0.8 for DS for balancing the transmitting condition. Fig. 4 shows that the simulation results of interference effects of FH, LBT and DS to DS. As in the case of Fig. 3 we use the duty factor of 0.9 for LBT and 0.8 for DS in Fig. 4.

Table 3. The interfering transceiver and victim transceiver's characteristics

Parameters	Tx	Rx
Channel spacing	<Table 4>	<Table 4>
Transmit power	10 dBm	-
Receiver bandwidth	-	<Table 4>
Cell Radius	10 m	10 m
Antenna height	1.5 m	1.5 m
Antenna gain	0 dBi	0 dBi
Active interferer number	1	-
Sensitivity	-	-83 dBm
Out of band emission	-36dBm/1MHz	-
C/I	-	25 dB

Table 4. System bandwidth for calculation the balancing factor

		Case1	Case2	Case3	Case4	Case5	Case6
FH	250kHz	25kHz	125kHz	250kHz	2.5MHz	6.25MHz	25MHz
	500kHz	50kHz	250kHz	500kHz	5MHz	12.5MHz	-
LBT(500kHz)		50kHz	250kHz	500kHz	5MHz	12.5MHz	-
DS(500kHz)		50kHz	250kHz	500kHz	5MHz	12.5MHz	-

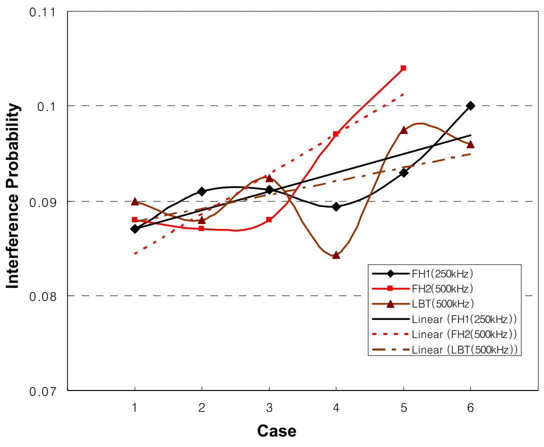

Figure 1. Simulation results of (FH, FH) and (LBT, FH)

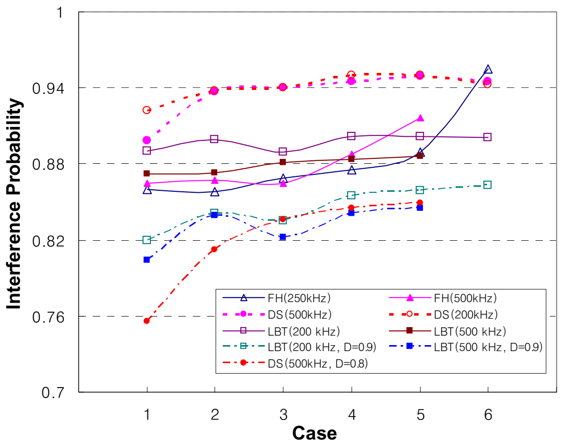

Figure 2. Simulation results of interference effects to FH systems

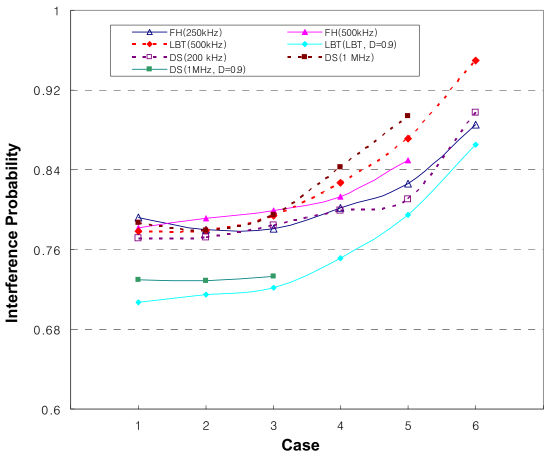

Figure 3. Simulation results of interference effects to LBT systems

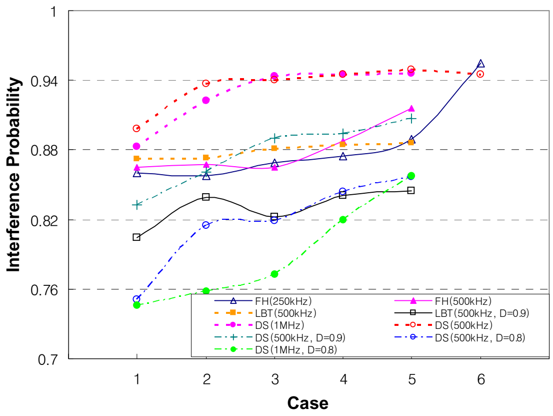

Figure 4. Simulation results of interference effects to DS systems

4. Conclusion

In case the other systems tries to share the already allotted frequency, interference between same system can be used as the frequency share decision criteria. In case of the interference probability by the new system being the same or being smaller than the interference probability between the systems being used currently, the frequency share of the new system can be allowed. When the new frequency is assigned or the frequency is relocated, it is desirable to use with the interfere avoiding technology in order to enhance the frequency use efficiently. The balancing factor is introduced between the interfere avoiding technology, and appropriate technical standards can be easily applied.

References

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