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## Conference Paper

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# The Outlook on White Space Utilization Policy in Korea

Lessons from the DTV leading Countries, namely, the US, the UK, and Japan

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*Abstract*— Some countries have already finished or are progressing toward a transition to Digital Television (DTV). In particular, the US and UK have conducted technical analyses of white space, and its management strategy is under review. They are also working on determining what kind of service could be used for white space. According to this trend, a special research team led by the Japanese government was formed to study DTV white spaces utilization, and its study was conducted at the end of July 2010 [1]. In Korea, a study was recently begun on Cognitive Radio (CR) that could be applied for white spaces. However, no official research is being conducted to quantify the available spaces and their management strategy depending on the service applications. In this paper, we propose an appropriate spectrum management scheme for white space in Korea considering the results of a survey, “Spectrum Requirement According to DTV Transition”, and an iconography review based on tentatively assigned DTV channels around three DTV pilot test areas, Uljin, Danyang, and Gangjin.

*Keywords*- White space, DTV transition, Spectrum policy, Spectrum demand survey, Iconography review, Spectrum management

## I. INTRODUCTION

Radio frequencies are limited natural resources and should be managed and utilized efficiently for the public interest and the promotion of industry. Nowadays, spectrum management authorities all over the world are in the process of modernizing spectrum policies and are seeking alternative spectrum management models which allow much more efficient and flexible utilization of the spectrum. Therefore, the lack of spectrum should be addressed by using the frequency sharing method and its management techniques [2].

In general, the RF spectrum is divided into fixed and non-overlapping blocks, separated by so-called guard bands, and it is exclusively assigned to serve individual services with various wireless technologies. However, spectrum could be considered and utilized as a resource of the time and the space. From an economic point of view, there appears to be a paradox, it that licenses for the RF spectrum are fully assigned, but a

large portion of the RF spectrum remains unused in practice when considered on a time or geographical basis [3]. Under the current command and control model, it is very difficult to make the unused spectrum available. In this regard, the development of a new frequency management model based on deregulation and wireless techniques such as dynamic spectrum access (DSA) and a dynamic spectrum management model should be considered and reflected in the spectrum policy for the enhancement of spectrum utilization.

Cognitive radio (CR), as a technology, is a tool to realize this goal of dynamic spectrum access and has been examined as a key technology of white space applications in order to protect incumbent users in the DTV band. Regarding this, ITU-R and IEEE are working on the standardization of spectrum sensing techniques that can be applied to white spaces [4].

However, this technique cannot yet be guaranteed for commercialization at present [5]. In addition, white space cannot be allowed over an entire country with the same bandwidth because of different DTV channel conditions due to terrain effects and the number of regional incumbent users.

For such situations, the US and UK have completed a general review of operating conditions of white space devices and they are currently reviewing white space management to increase the efficiency of frequency resources at the DTV band [6], [7]. Similarly, the Ministry of Internal Affairs and Communications (MIC) of the Japanese government officially reviewed DTV white space utilization and concluded its study at the end of July 2010 [1]. Meanwhile, in Korea, there are no official activities for the investigation of DTV white space up to the present, although there is planned transition to DTV within two years [8].

In this paper, we focus on the outlook of white space utilization in Korea. In section II, white space trends in leading countries, namely, the US, the UK, and Japan, were examined to find the major stream of white space utilization strategies. Then, we reviewed the spectrum demand survey through stakeholders associated with DTV transition to estimate the spectrum requirements in Korea. Then, based on a tentative

DTV channel layout plan for Korea, an iconography review to estimate available white spaces was conducted to target three pilot areas, Uljin, Danyang, and Gangjin. Finally, we present our views on white space utilization policy and discuss are of future research for more practical policy implementation.

## II. WHITE SPACE TENDENCY

After the DTV transition, some white spaces in the DTV band can be found depending on their geographical locations and it may be considered as a niche of the radio spectrum. By using these spectra, we might expect to increase the spectrum efficiency under 1 GHz. To realize this, white space devices (WSDs), intended for use in DTV white spaces, should keep listening for primary user voices in order to withdraw from the spectrum when a primary user starts accessing their own bands. In other words, WSDs should monitor RF conditions and available spectrum among white spaces to cope with interference against DTV. In such circumstances, the leading countries for DTV transition, especially the US, the UK, and Japan, are pushing for institutional improvement and taking measures to introduce the new wireless service.

In the US, white space as an unlicensed band was reviewed and it was decided that it should be exempt from licensing as a result. The Federal Communication Commission (FCC), the US government agency for communications, has conducted the test twice and has established a legal basis for using the white space without obtaining a license [6]. In addition, the FCC created an international TV White Space (TVWS) fellowship and a training initiative in order to encourage white space utilization [7]. The FCC also announced a plan to build a White Space Database (WSDB) for building a political infrastructure [9]. Recently, the FCC has assigned some channels for microphone and amended the required items for WSDs based on the opinions of stakeholders [10].

Similarly, in the UK, Ofcom, a regulator for UK communications industries, discussed white space utilization in the TV band and its techniques. Last year, they announced license exemption in TVWS [11]. Recently, Ofcom requested the opinions of stakeholders regarding WSDB operation plan [12].

In Japan, they officially started research on white space in November 2009. They will begin new wireless service using the spectrum in July 2012, although analog television (ATV) service is scheduled to be terminated by July 2011. To review and develop new services via white space, the ministry conducted a broad request for proposals for about one month, from December 11<sup>th</sup> 2009 to January 12<sup>th</sup>, regarding the use of white space. As a result, 103 proposals were received, and most of them were using digital signage or area One-Seg as a means of service delivery. The ministry expects positive economic effects through the enhancement of urban development and local job creation [1]. The decision-making progress of white space policy at the US, the UK, and Japan is described in Table 1.

## III. SURVEY RESULTS AND ICONOGRAPHY REVIEW

In December 2009, in relation to DTV transition, the Korean government officially announced a DTV spectrum plan to be implemented when ATV service is switched-off [8].

TABLE I. DECISION-MAKING PROGRESS OF WHITE SPACE POLICY

US FCC	<ul style="list-style-type: none"> <li>✓ Adoption a <i>Notice of Proposed Rule Making</i> for using WS as an unlicensed band ('04.05)</li> <li>✓ Adoption the <i>First R&amp;O/Further Notice</i> for TVBDs ('06.10)</li> <li>✓ Reporting OET test Results ('07.07, '08.11)</li> <li>✓ Public Notice for building WS DB ('09.11)</li> <li>✓ Adoption the <i>Second Memorandum Opinion and Order</i> for WSDs utilization ('10.09)</li> </ul>
UK Ofcom	<ul style="list-style-type: none"> <li>✓ Publication the <i>Digital Dividend Review</i> for discussion on idle spectrum and cognitive access at TV band ('05.11)</li> <li>✓ Publication the <i>Digital dividend: cognitive access</i> for statement on license-exempting cognitive devices using interleaving spectrum ('09.07)</li> <li>✓ Publication the <i>Digital Dividend: Geolocation for Cognitive Access</i> for making the WSDB operation plan ('09.11)</li> </ul>
Japan MIC	<ul style="list-style-type: none"> <li>✓ Launch the research team, called <i>A Study on Use of Radio New Vision</i> ('09.12)</li> <li>✓ Holding of international symposiums for <i>White Space Utilization</i> ('10.03)</li> <li>✓ Formulation of policy implementation and utilization of new effective use of White Space Radio ('10.07)</li> </ul>

The public notice also announced that the 228 MHz bandwidth from CH 14 to CH 51 in the current UHF TV band will be used for DTV and some other spectra in the VHF TV band will be left as the DMB band and the DTV spare band. The frequency plan for DTV is shown in Fig. 1.

Regarding the DTV transition plan in Korea, survey was conducted to examine the spectrum policy direction for tentatively residual frequency utilization after ATV service termination. In this regard, a variety of experts in this field were targeted from 246 organizations related to broadcasting and telecommunication including service operators. The survey was carried out through the cooperation of the Korea Radio Promotion Association. To facilitate the survey, a written or online process was conducted for about three months from November 2009 to January 2010. Out of 246 institutions, 113 responded to the survey, and these responses could be categorized by service fields and its applications. The application and its details including requirement spectra are summarized in Table 2.

As shown in Table 2, required bandwidths depending on the services were reflected in the current wireless technologies, and applications corresponding to the bandwidths were categorized by respondents' business areas. Analyzing the results, we found that most respondents hoped to use residual spectrum for industrial, broadcasting and public purposes. Meanwhile, some respondents had no intention of spectrum utilization for their businesses and were only observing the direction of policy for the residual spectrum.

Among spectrum requirements, mobile communications and broadcasting, 4G, ubiquitous sensor network (USN) and

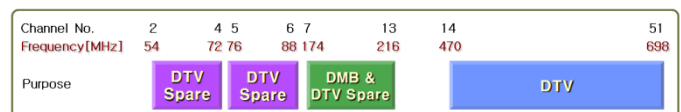


Figure 1. Terrestrial Digital Television Spectrum Plan

TABLE II. APPLICATION AND SPECTRUM REQUIREMENT

Category	Application	Details, Required Spectrum(MHz)
Industrial	<ol style="list-style-type: none"> <li>1. Mobile communication</li> <li>2. Universal Sensor Network(USN)</li> <li>3. Intelligent Transportation Systems(ITS)</li> </ol>	<ul style="list-style-type: none"> <li>• Supplemental Spectrum for 4G, 80</li> <li>• Video Transmission for Monitoring, 100</li> <li>• Tactical Mobile Network, 60</li> </ul>
Broad-casting	<ol style="list-style-type: none"> <li>1. Receiving environmental improvement</li> <li>2. Broadcasting for next generation</li> <li>3. Outdoor concerts &amp; special events</li> </ol>	<ul style="list-style-type: none"> <li>• Fringe area solution, 30</li> <li>• Relay Transmission for Mobile, 26</li> <li>• Multimode Service, 108</li> <li>• R&amp;D(3DTV, UDTV, etc), 12</li> <li>• Wireless Microphone, 50</li> </ul>
Public	<ol style="list-style-type: none"> <li>1. Public Agency &amp; Institution Communication</li> <li>2. Public Protection &amp; Disaster Relief</li> <li>3. Transport &amp; Monitoring Communication</li> </ol>	<ul style="list-style-type: none"> <li>• Regional Wireless Internet, 10</li> <li>• TETRA(TRS) service, 20</li> <li>• Vehicle Communication, 15</li> <li>• Intelligent Transport System, 10</li> <li>• Train Control, 4.4</li> </ul>

multimode service, were most in demand. These results seem to reflect international trend. Also, there were spectrum demands for a terrestrial trunked radio (TETRA) system as a public protection and disaster relief (PPDR) service and a DVB-T2 system as a mobile broadcasting service. Regarding the survey results, two kinds of applications, namely, industrial and broadcasting fields, require more than 30 MHz to provide seamless service to their subscribers. In other words, the main services such as multimode service or mobile communication service require more than 30 MHz to cover their service area. On the other hand, public services based on the respondent's answers were estimated to take less than 30 MHz including no business area in Telco or broadcasting fields such as a fringe area solution and R&D, 3DTV, UDTV, and so on. To explore the possibility of applying these required services to DTV white spaces, it is necessary to investigate how many spectra could be generated in DTV bands after DTV transition, and the DTV spectrum and channel assignment plan should reflect the derivation of white spaces in the DTV band.

As a part of DTV transition, Korea Communications Commission (KCC) chose three regions, Ulsan-gun, Gangjin-gun, and Danyang-gun, as demonstration areas [13]. Recently, KCC has announced that these pilot areas have successfully completed DTV transition [14]. Therefore, we selected these regions as target area for white space and examined the propagation distances for DTV relays through computer simulations in order to quantitatively determine the amount of white spaces. Regarding computing, most DTV transmitters and its relays in Korea are currently in operation around 2 kW and 10 W output power. Therefore, we simulated DTV service areas with a spectrum management tool that is based on ITU-R P.1546 [15], [16]. For this, we considered a DTV relay of CH 40, in a band from 626 to 632 MHz, with 10 W at 850 m altitude. As a result, the service coverage of the DTV relay reached around a 10 km radius due to the geographical conditions. The simulation results are shown in Fig. 2. Next, we calculated service protection regions based on the white space sensing level of the US, -114 dBm [6], in order to estimate the effective boundary of the DTV relay. For this, we considered the ETRI model for a suburban area in order to

reflect the propagation condition of the pilot areas in Korea. The model is [17]

$$PL[dB] = 40 \log d - \{10 \log(G_t G_r) + 20 \log(h_t h_r)\} + 20 \log f + 142.17 \quad (1)$$

where,  $d$  is a target distance in km,  $f$  is a carrier frequency, and  $G$  and  $h$  are the antenna gain and height of the target transmitter and receiver. The parameter in (1) is applied as the same condition in Fig 2. As a result, the effective area of DTV relays reached around a 15 km radius due to the ETRI model and the calculation results are shown in Fig. 3. According this result, we could consider a 15 km radius as unit of classification for neighbor regions.

Based on the computational results and tentatively assigned DTV channels for these areas, regional unoccupied channels, that is, white spaces, could be derived instantaneously. White spaces in the three pilot areas in relation to adjacent channel condition are summarized in Table 3 and white space quantities for each district were calculated depending on three situations according to neighbor DTV transmitter and relay conditions.

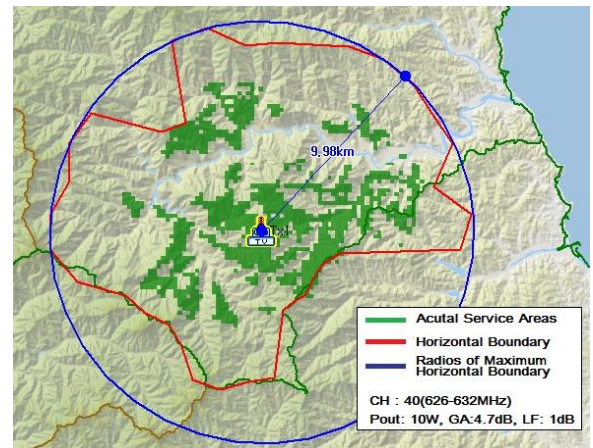


Figure 2. Service Coverage of DTV relay (@ P<sub>out</sub>: 10W)

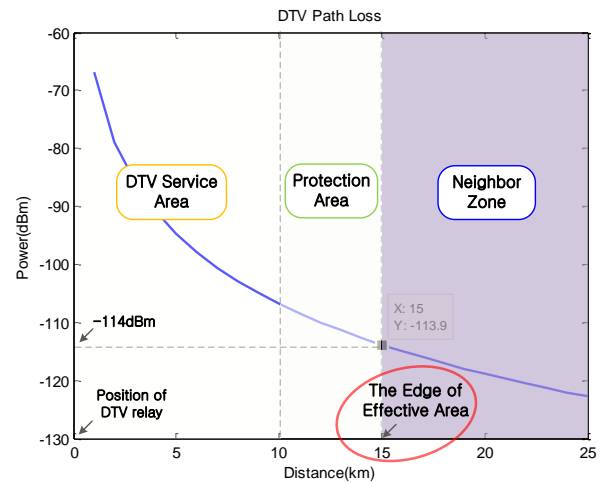


Figure 3. Effective Suburban Area Range (@ P<sub>out</sub>: 10W)



TABLE III. SPECTRUM REQUIREMENTS BY THE APPLICATIONS

Area	Condition(1.Light / 2.Normal / 3.Strict)	Unoccupied Space, ea.
Uljin	1. TXs & Relays in Uljin + 1 <sup>st</sup> adjacent region's TXs and Relays	● 12MHz space, 1 ● 6MHz space, 2
	2. TXs & Relays in Uljin + 1 <sup>st</sup> & 2 <sup>nd</sup> adjacent TXs + 1 <sup>st</sup> adjacent Relays	● 12MHz space, 1 ● 6MHz space, 2
	3. TXs & Relays in Uljin + 1 <sup>st</sup> & 2 <sup>nd</sup> adjacent TXs & Relays	● 12MHz space, 0 ● 6MHz space, 2
Danyang	1. TXs & Relays in Danyang + 1 <sup>st</sup> adjacent region's TXs and Relays	● 12MHz space, 0 ● 6MHz space, 4
	2. TXs & Relays in Danyang + 1 <sup>st</sup> & 2 <sup>nd</sup> adjacent TXs + 1 <sup>st</sup> adjacent Relays	● 12MHz space, 0 ● 6MHz space, 1
	3. TXs and Relays in Danyang + 1 <sup>st</sup> & 2 <sup>nd</sup> adjacent TXs & Relays	● 12MHz space, 0 ● 6MHz space, 0
Gangjin	1. TXs and Relays in Gangjin+ 1 <sup>st</sup> adjacent region's TXs and Relays	● 12MHz space, 0 ● 6MHz space, 9
	2. TXs and Relays in Gangjin + 1 <sup>st</sup> & 2 <sup>nd</sup> adjacent TXs + 1 <sup>st</sup> adjacent Relays	● 12MHz space, 0 ● 6MHz space, 2
	3. TXs and Relays in Gangjin + 1 <sup>st</sup> & 2 <sup>nd</sup> adjacent TXs & Relays	● 12MHz space, 0 ● 6MHz space, 1

The first situation is a radical condition in which unoccupied channel spaces are affected by DTV transmitters and relays which are located in the pilot areas and their first neighbor zones that have is 15 kilometers beyond the boundary of the pilot area.

Regarding the first neighbor zones, there are three or four districts adjacent to the pilot area. The second situation is a normal condition in which the channel is reflected by DTV transmitters located in the first and the second neighbor zones and DTV relays located in the first neighbors. Regarding the second neighbors, they have a radius 15 kilometers larger than the boundary of the first neighbors and cover more than ten districts. The last situation considers all of the DTV relays in the first neighbor zones from the second condition. As a result of the iconography reviews, one or more available channels could be generated intuitively except for the third case of Danyang. Therefore, considering the results of Tables 2 and 3, some frequencies of less than 2 units, 6 MHz per unit and totaling 12 MHz, are preferable to use as a white space. We can expect that white spaces may be more affected when the DTV relay conditions are changed. Also, it is suitable for small spectrum applications such as the public services listed in Table 2, which could be provided with 30 MHz or less.

IV. SPECTRUM MANAGEMENT SCHEME

In TV spectra, the traditional command and control spectrum management model has been applied for licensed operators so far. Such a model is limited in that some portions of the spectrum are hardly used to protect incumbent users [18], [19].

Especially, in the terrestrial DTV band, the right has been emphasized under the pretext of providing free universal service to the public. However, there are some stationary unoccupied spectra depending on the operating conditions of the regional DTV stations. Therefore, unlike other wireless services, the spectra in the DTV band can be used more efficiently if the management scheme for white space is planned according to a new paradigm in which unlicensed

services can coexist with the licensed services in the same region by geographical frequency reuse.

Through the survey and the iconography review, spectrum requirements of wireless applications and predictable unoccupied spaces in the DTV band could be derived. The first situation in Table 3 is a favorable condition to create lots of empty spaces. However, this situation would be interrupted by primary users, broadcasters, in order to protect their services. On the other hand, an extremely limited condition that does not take into account frequency utilization efficiency, such as the third situation in Table 3 could not derive unoccupied spaces as in the Danyang area. However, even in these areas, there is room for secondary users if empty space conditions could be alleviated to the second situation in Table 3. In this regard, a few bandwidths could be allowed as white spaces in the target area if some operating guidelines for mobile devices near the boundaries are given to assure the primary services. Thus, the second situation in Table 3 is reasonable to assume and calculate the quantity of white spaces considering two aims, namely, maintaining primary user protection and enhancing spectrum efficiency.

In order to achieve the second situation, it is necessary to establish a monitoring and protection scheme according to special spectrum management procedures that reflect the regional mobile device operating conditions and the complaining reports from primary users as shown in Fig. 4. In this regard, two specialized logical directions as shown in the flowchart in Fig. 4 can be considered as the white space management measures.

In Fig. 4, white spaces are derived under the strict condition, that is, the first situation, for the primary users at first. In case that no channels are available under the severe condition, the channels are reconsidered in terms of the normal condition, i.e. the second situation, in which the channel conditions are mitigated while limiting the operation scope of the second users. In addition, the applications can be operated indoors

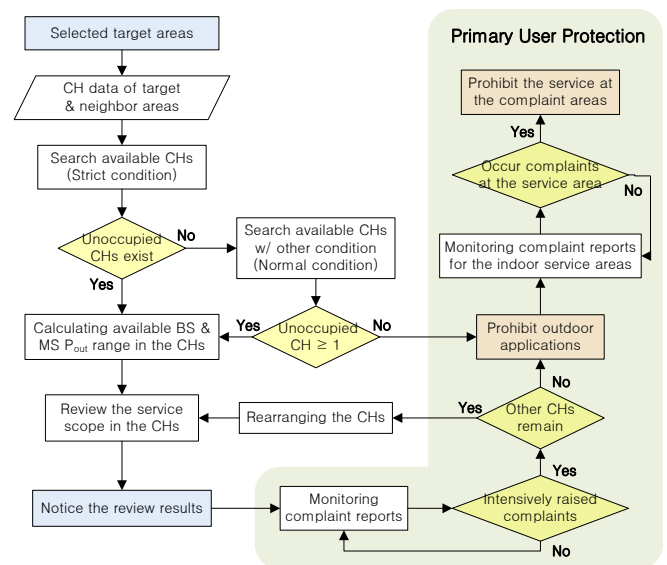


Figure 4. White Space Management Scheme

only if there are no more available channels in the target areas. However, for primary users, white space services including indoor only areas could be prohibited if complaints keep occurring in the target areas.

## V. CONCLUSIONS AND CONSIDERATIONS

In this paper, white space trends in three countries and the DTV spectrum plan in Korea were examined to predict the direction of white space utilization policy in Korea. Based on these reviews, the demand for frequencies could be derived through the results of stakeholder surveys. The amount of white space for each pilot project region was estimated through an iconography review based on the DTV channel layout plan for the regions. Based on these results of these, we predict that only few DTV channels can be available as a white space and be used for small-spectrum applications, such as public services or non-profit activities, such as a fringe area solution and R&D. These applications do not require many frequencies as shown in Table 2. Based on these results, we proposed the white space management strategy to support a coexistence environment with license exemption services in licensed operator regions.

In this paper, we considered all broadcasting channels in target areas and its neighbor regions in order to reflect severe conditions. However, this assumption could be changed depending on the financial condition of broadcasting operators. Therefore, the quantification of the actual spaces should be examined by conducting an installation planning survey based on their financial conditions. Moreover, the government should consider developing detail white space schemes considering all perspectives in order to reach a social consensus. As a precondition for achieving the amendment of relevant laws and regulation such as the 'Broadcasting Act', primary users, that is, broadcasters, should be considered and protected by a special management plan for the operation of white space as shown in Fig. 4.

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