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Implications of Incentive Auction : Focusing on key issues in U.S.

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ABSTRACT

The Federal Communications Commission (FCC), which regulates interstate and international communications in the United States, has established a plan to allocate high demand spectrum to the usage of mobile communication by inducing voluntary relinquishment from broadcasters. This plan was introduced by the National Broadband Plan as an incentive auction in 2010. The FCC suggested the Notice of Proposed Rulemaking (NPRM) in 2012 and issued Report and Order (R&O) on May 2014 regarding the overall rules of incentive auctions expected to be implemented in mid-2015. The incentive auction attracts the attention of many countries because this policy suggests a novel approach regarding the alteration of use from an inefficient usage to an efficient usage in limited spectrum resources. In this paper, we define the key issues in order for implementation of incentive auction. Since the incentive auction is a highly complicated process compared to previous allocation procedures, a careful review of the incentive auction regarding whether this spectrum policy can be introduced is required. In this paper, we describe the detailed procedure of the incentive auction and present policy considerations for the introduction of the incentive auction.

Key Words : incentive auction, spectrum allocation, FCC, making incentives, repacking, reimbursement

Ⅰ. Introduction

A long time ago, the value of a road was not significant because there were only a few cars available to drive. However, many people were highly concerned about the road after a substantial increase in the number of cars. The government, therefore, constructed highways to ease car traffic; however, citizens were frequently stuck in traffic jams due to the exponential increase in cars. The government tried to build additional highways to solve this problem; unfortunately, this could not be attained because residential or commercial buildings already occupied the most effective route.

In the mobile communication market, we can consider a spectrum to be the road, when we use cars as data. In the early 1990s, the concern of spectrum was not significant because the development of Information Technology (IT) was not substantially improved. Recently, however, access to traffic data has surged due to increasing subscribers and the penetration of smart phones. Thus, we have suffered problems such as disconnected data services and poor call quality. The main reason for these problems is the shortage of spectrum; therefore, mobile operators have pursued a way to retain sufficient spectrum. However, like the aforementioned highway case, the highly efficient spectrum bands are already used for other purposes.

In this circumstance, the regulator in the United States, the Federal Communication Commission (FCC), suggested an incentive auction for allocations

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of mobile telecommunications usage by inducing the volunteer relinquishment spectrum previously allocated for other usages. The incentive auction is a series of spectrum allocation procedures repacking the voluntarily relinquished spectrum from broadcasters, and then this secured spectrum by repacking is allocated to the usage of mobile telecommunications using an auction mechanism.

In 2010, the FCC[1] introduced an incentive auction in the National Broadband Plan as one provision to secure broadband for mobile telecommunication use. In 2012, the Middle Class Tax Relief and Job Creation Act was enacted, granting permission to implement an incentive auction; based on this ruling, the FCC[2] suggested the Notice of Proposed Rulemaking (NPRM) regarding the provisional rule of incentive auction. Furthermore, this policy has been steadily improved through the operation of task force teams to review the detailed incentive auction rules and the opinions of predicting possible problems from stakeholders. In addition, the FCC[3] issued the Report and Order(R&O) to adopt discussed rules regarding implementation of the incentive auction on May 2014.

The incentive auction is the first trial to allocate voluntarily relinquished spectrum to other usages; thus, this policy has caught the attention of global eyes. However, except for the United States, most other countries are not able to establish this novel allocation policy. This is because the incentive auction's procedures are highly complicated. This policy consists of three steps: (a) reverse auction to induce the volunteer relinquishment of spectrum, (b) repacking to rearrange the relinquished spectrum and broadcasting channels, and (c) forward auction to allocate the secured spectrum by repacking to other usages[2].

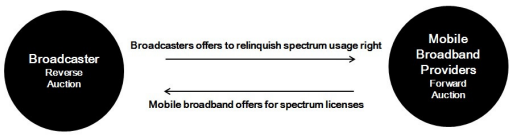

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Fig. 1. Diagram of incentive Auction

Ⅱ. Overview of Incentive Auction

As previously mentioned, the incentive auction consists of three major steps: (a) reverse auction, (b) repacking, and (c) forward auction. Even though these procedures seem distinctively separate, in fact, these sequential steps are organically related. Reverse auction is a procedure to decide how many broadcasters, who are willing to relinquish their spectrum usage rights, receive incentives. Forward auction is a procedure to decide how many mobile operators, who are willing to use the relinquished spectrum for their own purpose, pay according to auction results. Repacking is a bridge role between reverse auction and forward auction and exists in order to ensure broadband by reorganizing relinquished spectrum and broadcasting channels.

There are several reasons why these three steps should be coherently organized in the incentive auction. First of all, the sufficient amount of spectrum should be guaranteed for the success of forward auction. If the amount of ensured spectrum is not sufficient to allocate to other uses, the demand of spectrum would be low, resulting in relatively lower spectrum pricing compared to the expected spectrum pricing by the FCC. Simply, however, the sufficient amount of ensured spectrum cannot guarantee the success of forward auction. In repacking, it is crucial to build allocation blocks such as broadband, which is in high demand in the market.

In addition, the termination of incentive auction is dependent not only on the profit of forward auction but also the cost of reverse auction and repacking[4]. The broadcaster who voluntarily relinquishes rights for spectrum use receives the portion of forward auction results as an incentive. Also, in repacking, the cost of rearrangement of spectrum and broadcasting channels is estimated. If the profit of forward auction is less than the incentive offered to the broadcasters in reverse auction and the cost that will be occurred in repacking, the incentive auction cannot be completed. In this case, the FCC should

attain additional relinquished spectrum from broadcasters or draw more efficient repacking results. However, these trials may cause an adverse effect on the schedule of overall incentive auctions, resulting in additional costs. Thus, the FCC would like to minimize the potential problems in these sequential steps with discretion.

2.1 Reverse Auction

The reverse auction can be considered a procedure to voluntarily relinquish the usage rights of spectrum. In this step, the incentive that will be awarded to broadcasters who give up its spectrum usage right is determined.

First, we need to clarify the conditions of relinquishment of spectrum usage rights. The FCC[2] suggested three sorts of relinquishment options. The first option is that the spectrum usage rights and broadcasting will be wholly terminated after the incentive auction. The second option is channel sharing. In this case, a broadcaster gives up its 6MHz[1] spectrum, and then starts its own broadcasting with another broadcaster who equally chooses the second option. We note that they do not use 6MHz by separating 3MHz respectively; instead, they carry out their broadcasting using the same transmitter on the 6MHz. The last option is the change of spectrum band from UHF to VHF. If the broadcaster chooses this option, the rights of broadcasting will be maintained.

The FCC[2] also takes into account the sealed-bid auction and descending clock auction, as the mechanism of reverse auction. In sealed-bid auction, the winner is determined in only one round, and the bid represents the willingness to accept (WTA)[5]. On the other hand, the descending clock auction is implemented via several rounds by decreasing WTA as rounds goes by, and this approach progresses until the amount of expected spectrum by FCC is satisfied[5]. In general, the bidders of reverse auction prefer the descending clock auction over the sealed-bid auction[2]. In the sealed-bid auction, the bidder has the burden because he or she must precisely estimate the price of his or her own spectrum within only one round. However, in the descending clock auction, the bidder's burden is lower since he or she only determines whether or not to accept or deny a decision based on the current price in each round. On the other hand, in the position of the FCC, the sealed-bid auction is preferred because it can draw an auction result within a short amount of time; on the contrary, the descending clock auction is needed to develop the bid software and thus, it may take more time to finish the reverse auction due to the more complicated bidding procedures.

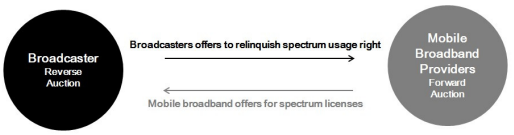

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Fig. 2. Reverse Auction

At the result of comparison of pros and cons between descending clock auction and sealed-bid auction, FCC has adopted the descending clock auction format for the reverse auction step in 2014[3].

2.2 Repacking

In the repacking, the channel rearrangement for broadcasters and the spectrum rearrangement for allocation to other services are included. Also, in this procedure, there are several conditions that should be considered, such as the winner of the reverse auction, interference among broadcasters after incentive auction, channel sharing, security of the broadband, and the cost to minimize repacking. Due to many constraints in this procedure, it is paramount to seek a suitable algorithm for repacking. The FCC[2] suggests two sorts of algorithms, integer programming and sequential algorithm.

Integer programming aims to find an optimal solution by satisfying objective function under constraints with a mathematical approach[6,7]. In terms of incentive auction, finding the best way for spectrum clearing under constraints is considered the

1) The spectrum width of a DTV channel in the United States is 6MHz.

aim. In this case, the objective function is the amount of spectrum that should be ensured and the constraints are the winners of reverse auctions, the costs in repacking, the rewards in reverse auctions, and the interference of the broadcaster after an incentive auction. However, because of highly complicated conditions, it is extremely difficult to find the optimal solution using integer programming. Thus, when the solution is estimated, the approximate solution is considered to be the optimal solution if the solution is converged within a proper criterion range.

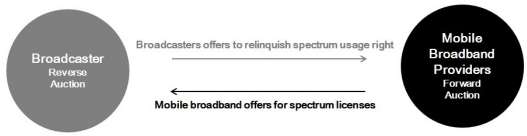
Sequential algorithm is an approach to sequentially find a partial solution via objective criteria, and then integrate partial solutions to an optimal solution[8]. In the incentive auction, using the objective criteria, the winner of the reverse auction is sequentially allocated to the remnant spectrum except of pre-allocated spectrum to other bidders. The repacking process is finished with sequential algorithm if the winner of the reverse auction cannot be allocated to any spectrum.

FCC[3] has adopted the sequential algorithm to evaluate the broadcasting channel allocation through a feasibility check because this algorithm is more fitted to descending clock auction in reverse auction step then the integer programming. Also, the feasibility checker using the sequential algorithm can be quickly progressed in each round of descending clock auction.

A well-proved computer software is needed to find a repacking solution; such software can mitigate the latent problems that can significantly hinder the smooth preceding of incentive auction. Thus, the FCC is focusing on the verifying of not only repacking algorithm but also repacking software[9].

2.3 Forward Auction

The forward auction is similar to spectrum allocation procedure, which was implemented by the FCC via auction mechanisms while the forward auction in incentive auctions has a prerequisite condition. In order for forward auctions to be successful, the securement of a suitable amount of spectrum is paramount. However, as previously



Source: FCC, Retrieved Aug., 23, 2014 from http://wireless.fcc.gov/incentiveauctions/learn-program/

Fig. 3. Forward Auction

mentioned, the bandwidth of one broadcasting channel is 6MHz; therefore, this bandwidth is highly insufficient and should not be referred to as broadband for mobile service. Hence, the FCC has a plan to merge a string of relinquished spectrum by broadcasters as broadband and this procedure is related to repacking.

The FCC[2] weighs in more on simultaneous multiple-round auction (SMRA) and ascending clock auctions considering generic block than on seal-bid auctions. A SMRA is an auction for multiple spectrums where the bidder can bid any spectrum that he or she has interest in during each round[10,11]. After each round, the winner and high-bidder is announced and the minimum bid increment is noted. As long as there is new bidding in any spectrum band, the auction is continued, whereby if there is no bid in every spectrum band, the auction is terminated. This auction mechanism has two major issues: (a) if the demand in the specific spectrum band is extremely high, the auction round can be excessively extended; (b) this mechanism cannot easily allow bidders to ensure the wide bandwidth. On the other hand, in ascending clock auction considering generic block, the bidder only represents the amount of generic blocks that he or she needs instead of bidding to specific spectrum band such as SMRA[11,12]. Here, the generic block means that the regulator intentionally divides the whole spectrum into an equal size block[2] for spectrum allocation. That is to say, regardless of the location of the block, only the width and number of the block are defined. In ascending clock auctions considering generic block, if the aggregated demand of generic block from bidders is greater than the supply of

2) FCC considers the generic block size to be 5MHz.

generic block prepared by the regulator, each generic price block will increase in the next round. However, unlike SMRA, the winner of each round is not determined. As the auction rounds progress, the value of the generic block increase; as a result, the aggregated demand of the generic block may decrease. Therefore, at a certain point, the demand of the generic block meets the supply of the generic block, meaning the condition of termination for moving forward with the auction. In the case of ascending clock auction considering generic block, it can be finished earlier than SMRA because the value of all blocks has equal quality. In addition, this mechanism allows bidders to attain broadband as the amount spectrum that bidders want. For those reasons, the FCC[2] acknowledged that ascending clock auction considering generic block is preferred over SMRA.

At the result of comparison of pros and cons between ascending clock auction and SMRA, FCC has adopted the ascending clock auction format for the forward auction step in 2014[3].

Ⅲ. The Key Issues of Incentive Auction

3.1 Making incentives

In the incentive auction, it is essential to make reasonable incentives for introducing relinquishment of inefficiently used spectrum to allocate to other usages. Also, the incentives should be determined by considering the spectrum allocation policy for broadcasting in each country. A few countries such as the United States, New Zealand, and Australia have adopted the spectrum policy that commercial broadcasters should pay the price for allocation of frequencies.

In the United States, the broadcasting frequency is taken into account at a spectrum that can be allocated via a spectrum auction. Table 1 shows the history of spectrum auctions for allocation regarding broadcasting usages. After introducing spectrum auctions in the United States, the first spectrum auction was implemented in 1999. Until now, Closed Broadcast (three times), New AM Broadcast Stations (one time), FM Broadcast (eight times), New Analogy TV (one time), Full Power Television Station Construction Permits (one time), Low Power Television Station (two times), and Broadcast Auction (three times) auctions have been performed. Among them, the Full Power Television Station Construction Permits (Auction No. 64) reaped the most bids based on each license and the Auction No. 37, FM Broadcast, was the greatest in terms of net winning bids.

Also, the regulator of New Zealand held the seven times spectrum auctions for commercial AM, FM, and VHF/UHF broadcasting frequencies from 1996 to 2008 and the regulator of Australia allocated 36 broadcasting licenses for commercial

Table 1. Broadcasting Spectrum Auctions Summary

No.	Year	Auction Name	Licenses Auctioned	Licenses Won
25	1999	Closed Broadcast	118	115
27	1999	Broadcast Auction	1	1
28	2000	Broadcast Auction	2	2
32	2002	New AM Broadcast Stations	3	3
37	2004	FM Broadcast	288	258
54	2003	Closed Broadcast	4	4
62	2006	FM Broadcast	171	163
64	2006	Full Power Television Station Construction Permits	11	10
68	2007	FM Broadcast	9	9
70	2007	FM Broadcast	120	111
79	2009	FM Broadcast	122	85
80	2000	Blanco Texas Broadcast	1	1
81	2005	Low Power Television (LPTV)	113	90
82	2002	New Analog Television Stations	4	4
85	2008	LPTV and TV Translator Digital Companion Channels	43	30
88	2010	Closed Broadcast	13	13
91	2011	FM Broadcast	144	108
93	2012	FM Broadcast	119	93
94	2013	FM Broadcast	112	93

Source: FCC, Retrieved Aug., 23, 2014 from http://wireless.fcc.gov/incentiveauctions/learn-program/

Radio and TV through spectrum auctions from 1996 to 2004. There is, therefore, solid evidence that the broadcasters in these countries can receive a certain level of incentive for voluntarily relinquishment of their spectrum usage rights.

On the contrary, in many countries, the broadcast spectrum license is not considered to be an item that requires the price of allocation. This is because, according to the spectrum policies in these countries, the broadcast spectrum license follows the approval of regulators. The broadcasters in these countries regularly pay a certain fee to the regulator. More specifically, the broadcasters in Japan annually pay the spectrum usage fee. The regulator in UK has a plan to impose an Administered Incentive Pricing (AIP) which is opportunity costs occurred by other usages. The regulator in Korea can collect a certain level of fees from broadcasters. The Korean broadcasters do not pay for allocation of frequencies and radio wave fees; instead, a specific amount of fees are paid for the Broad Communications Development Fund. However, it is not sufficient evidence that the broadcasters can receive any incentive by relinquishing its spectrum usage right via an incentive auction. By considering these countries' spectrum policies, "license fee waiver", "tax bonus", and "reduction in spectrum usage fee" can be taken into account alternatives of rewards in the incentive auction. However, it should be required to gather not only the opinions from stakeholders but also an in-depth legal review from the regulator regarding making incentives for implementation of incentive auction.

3.2 Broadcasting channel rearrangement

In repacking, the interference problem amongst broadcasters that may occur after incentive auction should be carefully reviewed. More specifically, If broadcasting stations that are highly close geographically are assigned the same channel or bordering channel, the deleterious interference would occur. Due to this possible problem, the Middle Class Tax Relief and Job Creation Act of 2012 regarding incentive auction, defined the role of the FCC to "make all reasonable efforts to preserve, as of February 22, 2012, the coverage area and population served of each broadcast television licensee." Therefore, the FCC is focusing on minimizing the possible problems in repacking, and is gathering opinions from stakeholders by suggesting three possible constraint options in channel rearrangement. In this paper, we handle these three suggested constraint options by the FCC, and represent the implication of repacking.

The first suggested option is to preserve the utility of broadcasting among users based on the number of users who cannot watch the broadcasting before the incentive auction. As of February 22, 2012, this option does not guarantee the utility of users who watch the broadcasting without any interference before incentive auction. As shown in Figure 4, through repacking, if the station C is assigned a channel that was assigned to station B before incentive auction, station C has an obligation to maintain the interference between station A and C within previous interference levels between station A and B, without regional consideration.

The first option is highly efficient to draw an optimal solution in repacking, resulting in an operational advantage for the FCC. However, there is a risk that unspecified users might be impeded the utility of broadcasting as this option does not take into account the utility of users who watch the broadcasting without any problems.

On the other hand, the second suggested option by the FCC to maintain the utility of users before incentive auctions is limiting the allowance region for interference between stations. That is to say, unlike the first option, this option has an aim to

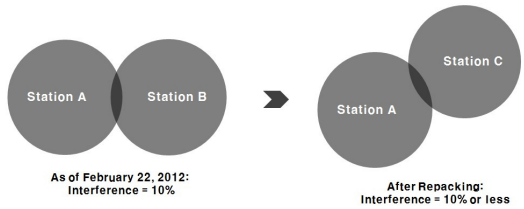


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Fig. 4. Option 1

eliminate the risk that unspecified users might prevent the utility of broadcasting. Figure 5 shows the application of the second option. In this case, station C is assigned a channel used by station B after an incentive auction. Unlike the first option, the allowance region of interference is limited to the specific region that existed in the interference between station A and station B before the incentive auction. The rule of interference level is the same as the first option; however, the allowance region for interference is specified in the second option. Therefore, in this option, the broadcasting utility of users who watch the broadcasting without any problem can be guaranteed. However, this option has disadvantage; the draw of optimal solution in repacking is more difficult compared to the first option because of the addition of regional constraints.

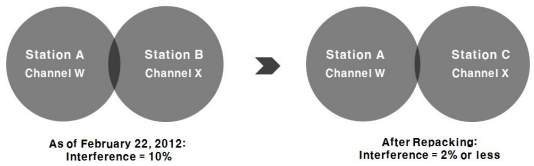
The third proposed option by the FCC is a compromise plan of the first option and the second option in terms of maintaining the broadcasting utility for specific users and the efficiency of drawing an optimal solution in repacking. In this option, the interference level and region is maintained among broadcasters before the incentive auction. If the new station is assigned the channel near the previous stations, the interference level is limited to 2% or less but there are no regional constraints.

For the review of this option, we examine two cases: bilateral relations and multiple relations. First, bilateral relations are represented in Figure 6. In this case, station C is newly assigned the channel that was assigned to station B before the incentive auction. Even though there was a 10% level of interference between station A and station B before the incentive auction, the interference level is limited to 2% in terms of station C. However, if Station A and Station B remain on the air after the incentive auction, the interference level is maintained only in the same interference region.

The multiple relations option can be explained in further detail. According to Figure 7, as of February 22, 2012, station A with channel W and station B with channel X were assigned. After repacking,

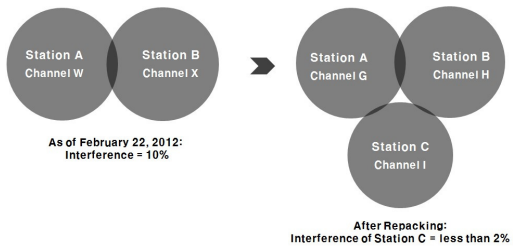
Source: FCC, Retrieved Aug., 23, 2014 from http://wireless.fcc.gov/incentiveauctions/learn-program/

Fig. 5. Option 2



Source: FCC, Retrieved Aug., 23, 2014 from http://wireless.fcc.gov/incentiveauctions/learn-program/

Fig. 6. Option 3: Bilateral Relations



Source: FCC, Retrieved Aug., 23, 2014 from http://wireless.fcc.gov/incentiveauctions/learn-program/

Fig. 7. Option 3: Multiple Relations

station A is altered to channel G, station B is altered to channel H, and station C is newly assigned to Channel I. In the relationship between station A and station B, the interference level is the same as it was previous to the incentive auction, 10% or less in the limited region where the interference exists between station A and station B. In the case of station C, which is newly assigned Channel I near station A and station B, the interference level is allowed within only 2% to the Station A and Station B, respectively. In terms of station C, the regional constraint is, however, not endowed.

This option can minimize the decrease of broadcasting utility for users by limiting the maximum allowance of interference, which is 2%, in the case of a new station. Furthermore, the regional

constraints only apply to stations that previously incurred the interference mutually, resulting in the capability to handle the flexible channel rearrangement.

FCC[3] has adopted the second option because FCC would like to maintain the utility of the same users before incentive auctions. Unlike other options, this option has an aim to eliminate the risk that unspecified users might prevent the utility of broadcasting. Also, FCC thought that this option will satisfy the objective of the FCC to "make all reasonable efforts to preserve, as of February 22, 2012, the coverage area and population served of each broadcast television licensee" that is described in Middle Class Tax Relief and Job Creation Act of 2012.

As previously mentioned, repacking is the unique step in spectrum allocation procedure. There has not been sufficient literature and studies regarding this step. Even though the FCC is developing a suitable algorithm and computer software to assist in the repacking procedure, it may take a long time to build and verify.

3.3 Reimbursement of channel rearrangement costs

After finishing an incentive auction, the FCC should reissue the broadcasting licenses according to the results of the repacking. The broadcasters who participate in incentive auction can decide on their selective auction: (a) going off the air (b) sharing the spectrum (c) moving UHF to VHF. In addition, there are some broadcasters who do not participate in the incentive auction and give up the incentive auction in the course of implementation of incentive auction. Therefore, careful reviews regarding not only how much to pay the reimbursement, but also who is eligible for receiving reimbursement regarding channel rearrangement, should be conducted. Some stations can go on-air after an incentive auction with only minor modifications, such as adjusting antenna location, renovating towers, or replacing the broadcasting facilities. Other stations have to meet a relatively high cost to satisfy the conditions of repacking by moving their towers or fully changing transmission facilities.

The Middle Class Tax Relief and Job Creation Act of 2012 offers 1.75 billion USD for reimbursement in repacking. The FCC should make this payment within 3 years of finishing the incentive auction; thus, it is paramount to build an efficient schedule and to correctly predict the expected costs for repacking. The FCC[2] suggested that the broadcasters who are eligible to receive reimbursement for repacking be allowed to choose the option of either advance payments based on estimated costs or actual costs of reallocation. Furthermore, the FCC limits the eligibility of reimbursement only to the broadcasters who are full power stations and Class A licensees. If channels are involuntarily reallocated via an incentive auction, the FCC should guarantee. On the other hand, even though the stations have a position of full power station or Class A license, the reimbursement should not be guaranteed when they choose the option of reverse auction among sharing a spectrum or moving UHF to VHF. In this case, these stations should reallocate channels using the incentive for relinquishing their spectrum usage rights via an incentive auction.

In sum, the FCC carefully reviews the management of repacking and reimbursement processes. For this issue, the FCC seeks comments on how to handle this procedure properly and how to more efficiently build a fund for reimbursement.

Ⅳ. Concluding Remarks

In this paper, we have presented detail process of the incentive auction and have defined the three key issues for implementation of the incentive auction. The incentive auction attracts the attention of many countries because this policy suggests a novel approach regarding the alteration of use from broadcasting usage to other usages in limited spectrum resources. As globally there are no cases already implemented, a regulator, that considers the introduction of incentive auction, might be requested a careful review regarding not only the spectrum policy but also the circumstance of spectrum usage.

In this paper, we have suggested three crucial conditions that should be reviewed before implementation of the incentive auction. First, it is indispensible to make reasonable incentives for introducing relinquishment of used spectrum to allocate to other usages. The suitable compensations for the relinquishment of spectrum rights are highly correlated with the success of the incentive auction. This is because the amount of accumulated spectrum through the reverse auction can significantly affect the results of forward auction. Moreover, the technical study on repacking procedures in the incentive auction also is needed for timely implementation of this policy. If broadcasting stations that are highly close geographically are assigned the same channel or bordering channel in repacking process, the deleterious interference would occur. Finally, the reimbursement of channel rearrangement costs in incentive auctions should be reviewed by considering the environment of each country's spectrum policy. There are some broadcasters who do not participate in the incentive auction and give up the incentive auction in the course of implementation of incentive auction. The regulator, who considers the introduction of the incentive auction, should fully support their channel rearrangement costs.

Without preparing a careful review of the incentive auction procedure, implementing an incentive auction might be delayed. For example, the National Association of Broadcasters (NAB) sued the FCC over a plan to implement an incentive auction[13]. The NAB pointed out that the broadcasting channel rearrangement methodology suggested by the FCC's Report and Order(2014) cannot satisfy the level of efforts "to preserve, as of February 22, 2012, the coverage area and population served by each broadcast television licensee" that is described in the Middle Class Tax Relief and Job Creation Act of 2012. Therefore, the NAB predicted that a significant interference of broadcasting would occur after completing the incentive auction. Moreover, the NAB indicated that the reimbursement of channel rearrangement costs in the incentive auction prepared by the FCC cannot fully cover the possible costs of channel rearrangement. Because of the lawsuit, the incentive auction plan would be delayed until mid-2015 to 2016. In light of this, the regulator, who considers the introduction of the incentive auction, should carefully review the detail procedures and possible problems of the incentive auction.

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