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TELECOMMUNICATIONS REGULATORY STRATEGIES IN SPECTRUM MANAGEMENT

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ABSTRACT
Nowadays, the application of wireless broadband has grown denser and tends to expand even more. This results in the soaring bandwidth needs to effectively support consumer demands. Besides, the growth in broadband connectivity through wireless networks has also brought about huge spectrum demands as well. As regards the soaring spectrum demands, if the regulators place importance on long-term spectrum planning through formulating the strategies and methods related to spectrum management, the country will be capable of supporting a great demand for spectrum in the future. The objective of this paper is to propose telecommunications regulatory strategies in spectrum management techniques to maximize the benefits of spectrum resources as well as creating economic and social values for the country.

INTRODUCTION
Regulators in several countries worldwide mainly make spectrum allocations using the market mechanism to provide operators with an easier and faster spectrum access, and to effectively fulfill the spectrum demands for wireless network services. In some countries, spectrum management can be performed through refarming so that the required bands will be used for specific purposes. However, in some countries, the licensing approach is adopted on the condition that the full or partial transfer of spectrum usage rights can be carried out. This aims at providing higher chances of entry for micro operators or to allow greater flexibility in operations among the licensed operators who are facing disruptions from the lack of financial liquidity. Furthermore, in some countries, the regulators may grant license exemptions to enable the self-manage spectrum to flow more freely among operators.

Spectrum usage in mobile networks has greatly expanded affecting telecommunications industry's spectrum needs to soar rapidly. According to the 2011- data traffic forecasted by the International Telecommunication Union Radiocommunication Sector (ITU-R) in 2006, the actual 2011- data traffic was 5 times greater than the amount estimated by the ITU-R in 2006. Furthermore, the ITU-R also forecasted that the mobile broadband traffic in 2011 will be 8 times grower during 2010-2011 as shown in Fig.1 [1] [2] [3].

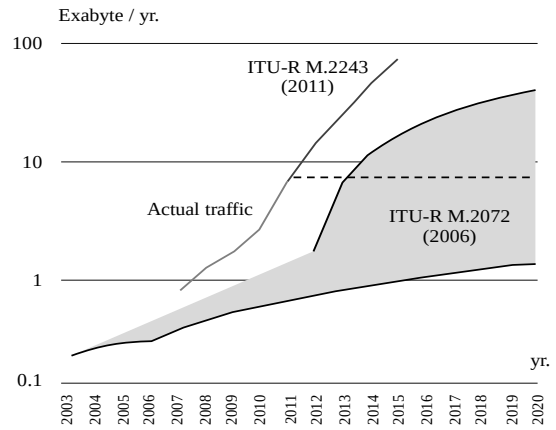

Fig 1 : The data traffic in 2006 and 2011 forecasted by the ITU-R [1] [2]

In many countries, to double the amount of spectrum within the duration of less than 6 years or by the end of 2020 according to the ITU's suggestions is quite practically hard-to-achieve because there are several legal restrictions regarding the negotiation urging the incumbent users to return spectrum. However, the

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aforementioned number forecasted by the ITU may not match actual utilization rates due to several different internal factors. Therefore, additional studies related to domestic average spectrum demands are considered important in that the data can be used to draw up distinct future plans [4] [5].

Accordingly, the formulation of plans to study further demands for domestic average spectrum and the possibility of managing spectrum through different approaches apart from the exclusive-use licensing done previously, especially the shared use of spectrum (both open to group and public), provide more options fulfilling the increasing spectrum demands.

Although telecommunications is one of the key infrastructures that take part in propelling the country's development in terms of economy, society, education, public health, science, national security as well as bring about social equality, there has had no clarity on the concrete benefits it will offer to the society. This especially includes the benefits in terms of public disaster prevention and relief as well as scientific research and development which are also considered important compared with other aspects. Therefore, it is necessary that the spectrum demands should be taken into consideration as well.

RESEARCH METHODOLOGY

The objective of this research is to propose the telecommunications regulatory strategies in spectrum management techniques. This research is the qualitative research approach based on in-depth interviews and supported by inputs of secondary data from academic papers, business and best-practices reports made by respectable reference sources. Its primary data will come from in-depth interviews of distinguished experts in related fields under the following research framework as illustrated by Fig.2.

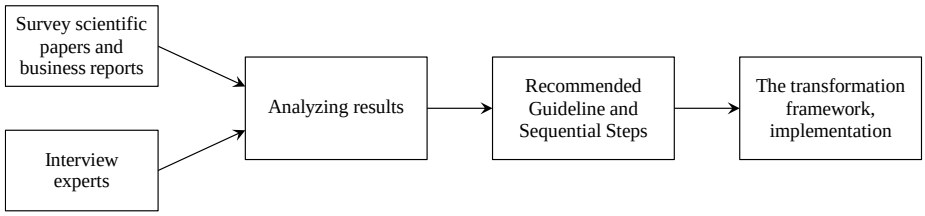

Fig 2 : Research framework

The experts sought for in-depth interviews for this research are those from four academic fields as shown in Table 1:

Table 1: Interviewing experts and key focus

Area of expertise	Numbers
Spectrum management	3
Telecom Engineering	3
Information Technology	3
Policy and strategy	3

The in-depth interviews for this research focused on four fields directly related to the issue of spectrum management, telecom engineering, information technology, and policy and strategy, with 3 experts from each field adding up to a specialist group of 12.

Inputs from the in-depth interviews will be processed and analyzed together with secondary data which will be collated into a preliminary draft conclusion to be forwarded to the 12 experts for further comments with an intention of streamlining them into a shared common direction. The version assessed and scrutinized by the 12 experts will then be adopted as a basis for concluding the results to achieve the objective of the research.

In the following sections, the proposal telecommunications regulatory strategies are introduced. Section 3 describes how to utilize technological innovations that will result in effective use of spectrum. Section 4 introduces the Licensed Shared Access (LSA) techniques to yield the maximum efficiency. In Section 5, creating supportive policies are addressed to reduce the barrier of spectrum utilization. Section 6 describes the

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incentive-based approach and considers the digital dividend spectrum in 700 MHz into practical use. The last section is the conclusion.

SUPPORTING THE APPROPRIATE USE OF TECHNOLOGICAL INNOVATIONS

The appropriate support of technological innovation utilization will result in the effective use of spectrum that promotes telecommunications to be developed adequately for user demands. Some examples of technological innovation utilization are as follows.

1. UTILIZATION OF MOBILE NETWORK TECHNOLOGY ALONG WITH WI-FI

Developers of the technology for mobile and Wi-Fi networks have commonly perceived the importance of making continual progress in technology in terms of taking the most advantage of spectrum utilization, network capacities, network data transfer speeds, user experiences, including the effective integration of technology and the remarkable revolutionary modes which correspond to one another. These affect the utilization of core technology in mobile networks such as HSPA and LTE along with Wi-Fi to attain massive global success and be able to offload partial data to the Wi-Fi networks, often called Wi-Fi Offload, to relieve as much burden placed on *mobile networks as possible*.

In addition, the use of small cells and femtocells which have a low output power in a large amount along with the existing macro cells to improve the efficient of the macro cells can further increase the overall network capacity in dense urban areas.

According to the study of Cisco undertaken in February 2014, it is found that 45 percent of the global mobile data traffic was offloaded through Wi-Fi and femtocells, and this particular number will be grower than the amount of major mobile data traffic by 2018 [6].

2. UTILIZATION OF HIGHER-BAND SPECTRUM

Recently, the use of low-band spectrum (such as 300 MHz and 3 GHz) has been massive in quantity and is getting denser every day. Accordingly, the technology developers and other related sectors have begun to place importance on using higher-frequency bands because their utilization is low in density. For example, the 2.4 GHz and 5 GHz spectrum was widely used in the Wi-Fi services previously, but there has been some development undertaken to make the 60 GHz band applicable based on the 802.11ad standard. For the sake of high-speed short-range communication and satellite communication services, the use of spectrum has been expanded up to the 28 GHz band compared to previously when only the spectrum below the 12 GHz band was commonly used. There will be an increasing trend of high-band spectrum utilization due to the growing demand for higher capacities to support new technologies. Meanwhile several technologies have been developed and gain widespread use, the cost of spectrum utilization in high bands tends to be lower [7] [8] [9].

3. TV WHITE SPACE (TVWS)

"White Space", in this case, refers to the unused channels available in the terrestrial television spectrum. Normally, the terrestrial television system in each area will use some of the channels and spare white spaces to avoid interference between channels. During the past ten years, there have been some extensive studies undertaken, especially in USA, to put the white space channels into use for expanding network coverage to remote areas in particular, known as the TV White Space (TVWS) technology [10].

Generally, the Wi-Fi signal in both the 2.4 GHz and 5 GHz bands can cover the area of a few square meters and can penetrate through merely two layers of wall. However, the white spaces of the spectrum band 470 – 790 MHz can travel up to 10 kilometers through cultivation areas, buildings, houses, and many others. So, they can be used as media delivering wireless broadband Internet connectivity to electronic devices such as a tablet computer, cellphone, and computer through fixed or mobile base stations, using a low-cost system. Therefore, the white spaces are appropriate for providing wireless broadband Internet services in remote areas or in areas where fixed-broadband Internet services are still out of reach stemming from high wiring costs. Bases on this, the amount of truly applicable white spaces will vary among individual areas.

Though the majority of client devices are still cannot connect to the TV White Space (TVWS) directly, most of TVWS devices commonly have ports for connecting to regular Wi-Fi hubs. This enables the client devices

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available in current markets to be capable of accessing Internet, using the TVWS technology as a connection medium

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4. UTILIZATION OF OTHER TECHNOLOGIES

There are a large number of technologies developed to enhance in spectrum utilization efficiency, both over the licensed and public spectrum. This includes the Ultra-wideband and Spread Spectrum (UWS) that spreads the signal over a wide-spectrum range using a very low output power so that the incumbent or primary users can share the spectrum with secondary users of UWB without causing interference. Therefore, it is suitable for short-range transmission and indoor purposes accordingly.

The software-defined Radio (SDR) is a radio communication system where the signal processing software has been typically implemented in general hardware and the technology can be adjusted to support various wireless protocols (such as GSM, WCDMA, HSPA, LTE, Wi-Fi, etc.). With the appropriate software utilization, this kind of technology is convertible depending on spectrum and interference. It is normally used with the Cognitive Radio (CR) that is capable of understanding and learning from previous operations and will adjust its own behaviors, according to unused channels and the amount of interfering signals, through adjusting the receiving and transmitting techniques appropriately at all time [11] [12].

SUPPORTING THE SHARED USE OF SPECTRUM

For many centuries, the spectrum regulators worldwide have placed emphasis mainly on the allocation of spectrum through providing “exclusive use” to allow particular license holders to have full control over the use of spectrum bands, driving network operators to acquire the utmost confidence in operating businesses. However, this approach is not exactly the best policy because there is inadequate spectrum available for the soaring demands, especially when the appropriate spectrum bands have already been allocated. Therefore, the study of possibilities enabling the shared use of spectrum through providing Licensed Shared Access and allocating the public spectrum which does not require further licenses has to be undertaken in response to the fast growing technology that increases the enormous spectrum demands.

The spectrum is, as a real, the resource that can be shared among users if there is some technology making the shared access possible without any interference, although the same spectrum band, area, or time of usage is being shared. This includes providing the allocation mechanism that enables the shared use of spectrum to yield the maximum efficiency. For example, Licensed Shared Access (LSA) is introduced to regulate the use of spectrum that is held by non-mobile incumbent users, has a low utilization rate, and is unable to shift its function for other purposes in the near future. Accordingly, the LSA users are allowed to use the entire or partial spectrum in the same band as same as the authorized incumbent users under exclusive licenses who may appear in the form of government or private organizations. This depends on the regulations on the shared use of spectrum and the right to use spectrum where the quality control can be carried out.

Initially, Qualcomm and Nokia suggested the regulatory method known as the Authorized Shared Access or ASA which aims at promoting the use of some spectrum bands which are not being used by primary users at a particular time and location for the sake of International Mobile Telecommunications (IMT), whereas the primary users can still make use of that particular bands us usual and be able to make plans for utilization forecasting. Later on, the ASA concept had been expanded by the Radio Spectrum Policy Group and finally gave rise to the LSA. However, the ASA and LSA are both considered based on the same basic concept [13] [14] [15].

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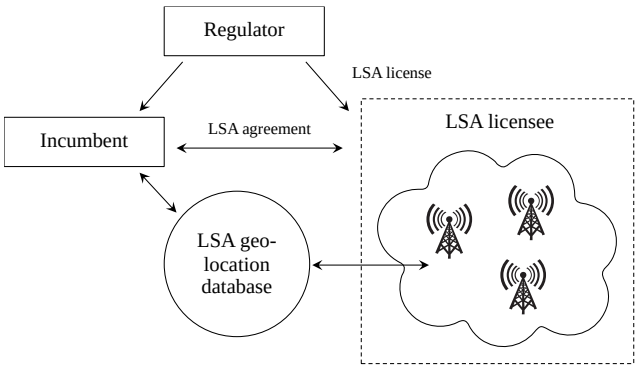

Fig 3 : The structure on spectrum allocation on the basis of LSA [15]

The LSA licensing-related sectors can be categorized into several major groups, i.e. spectrum regulators, incumbent users, and future LSA users. The motivations that may promote the aforementioned related sectors to follow the method of LSA can be describes in Table 2.

Table 2: Motivation promoting the shared use of spectrum (LSA)

Related Sectors	**Processes of Generating Motivations to Follow the Method of LSA**
Spectrum Regulators	The motivation for spectrum regulators is that the manipulation of spectrum based on the LSA method will help the regulators be capable of responding to the demands for public and commercial services. Under the condition where the transmission of data using mobile devices take a quantum leap in its growth, the growth of spectrum utilization then gets higher consequently. The use of LSA in spectrum management will be considered one of the strategic tools that the regulators can consider a choice providing mobile telephone network providers with access to spectrum during appropriate time, in case the incumbent users have never made the maximum use of the spectrum for a long time.
Incumbent Users	The incumbent users will be under the protection of spectrum usage rights, in the same way that the LSA users are eligible to access and make use of the spectrum that is not using by incumbent users. Accordingly, the incumbent users may view that the management of spectrum on the basis of LSA is a method contributing to cost reduction through allowing the authorized LSA users to use the spectrum. Moreover, the incumbent users also have rights to forecast and regulate the use of spectrum in a long run, and may gain payments from LSA users, based on the aforementioned method.
Future LSA Users	At the first stage, the LSA users must have an understanding of when and where the spectrum is unused throughout the period of spectrum license to ensure that they can use the spectrum in a particular location or at a particular time. This can facilitate them the considerations for investment decision-making. Furthermore, there should be some clarity and legal certainty in terms of regulations on the shared use of spectrum which will promote permission requests on the predictable basis. This will benefit the business forecast and assurance of service quality which will strengthen the motivation on device and networks of LSA users.

Utilization of the spectrum that has not been used at its maximum capacity in wireless broadband services will benefit the country in terms of economy. According to the studies of SFC Associates Ltd. Conducted among EU countries, it is found that the increasing shared use of spectrum in 200 – 400 MHz band for wireless broadband services will result the EU in gaining economic benefits of several tens of billions of euros by 2020. Moreover, it also provides the certified operators on the basis of LSA, known as LSA users, with immediate access to the spectrum without the need for allocation made by spectrum regulators. This is considered a method responding to the leapfrog growth in spectrum utilization [16].

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However, the Mobile Network Operators (MNOs) can expand their service capacities through utilizing the spectrum unused by incumbents in the area with high demand density for data services. This can be carried out without further investments in infrastructures because the operators can use the ones that have already existed, resulting in lower service prices. Similarly, the study of GSMA also points out that the shared use of spectrum on the basis of LSA can give rise to the economic benefits from making use of the spectrum that has been currently non-beneficial. This can be done through using shared spectrum and saving costs of investments in the shared spectrum among operators [12].

The allocation of spectrum on the basis of LSA is considered a way to make efficient use of spectrum. It may be appropriate for applying to the spectrum already utilized by the government sectors. Consequently, it should be flexible enough for the incumbent licensees to be capable of improving their own networks as well as should enable both the incumbent licensees and certified LSA users to use the spectrum and adjust themselves to technological changes in conformity with the spectrum usage rights acquired.

In addition, the use of TV White Space technology (TVWS) is also an example of spectrum sharing between terrestrial television and wireless broadband service providers or the users who directly use the spectrum in the TVWS band. There is a possibility that the shared use of spectrum along with this particular technology may be considered the integration between the licensing of a model called Licensed Shared Access for wireless broadband providers and the liberalization of spectrum usage in the form of Unlicensed Spectrum, as long as the standard for related TVWS devices are guaranteed by regulators [17].

SHAPING UP POLICIES TO BE MORE OPEN AND CONFORM TO THE DEVELOPMENT OF TECHNOLOGY

The obstacles for spectrum management arising in many countries have created barriers to the development of the telecommunications industry and make the preparation for future growth become very difficult. Therefore, creating supportive policies should be addressed as follows.

1. PROMOTING THE BALANCED USE OF MISCELLANEOUS POLICIES ON SPECTRUM ALLOCATION

Comparing the allocation of spectrum with that of land (owned by the state), there will be a great demand of high-valued land in business areas and the auction where the sale is awarded to the highest bidder is considered a suitable mean of allocation. However, the state may opt to allocate wastelands on lease to low-income agriculturists or allocate the community land for public benefits: building hospitals, public parks, schools, etc. Similarly, the allocation through auctions alone is commonly inappropriate for every band of spectrum. Therefore, the balanced implementation of miscellaneous methods on spectrum allocation tends to be more proper based on the 3 international practices as follows.

(1) Administrative approach such as to collect annual fee, set up middle price to seek for buyers, and to allocate spectrum for public benefits
(2) Market approach such as spectrum auctions, spectrum trading in secondary markets or leasing
(3) Spectrum sharing approach such as using Licensed Shared Access and allocating a certain proportion of open spectrum, etc.

2. MORE OPENNESS TOWARD SPECTRUM USAGE RIGHTS

The law placing restrictions on giving spectrum usage rights exclusively only for particular licensees brings about 2 major problems as follows:

(1) The restrictions obstruct other individuals to use the shared spectrum, though the use may not exert any effects on the primary licensed users. This goes against the global trend of spectrum allocation that places heavy emphasis on using shared spectrum by various means, especially for the 5G technology obviously designed to support the allocation which allows only one user to exclusively access the spectrum, the allocation which allows a group of users to exclusively access the spectrum, an open access that enables unlimited numbers of unlicensed users to share spectrum.

(2) Disallowance of transferring spectrum usage rights points out that though the performance of licensed service providers is not adequate for operating businesses successfully or there is no need for using all or partial spectrum available, such providers cannot resell or lease rights or others but have to take possession of spectrum

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until the license period expires. This contributes to the rise in barriers to new entry, passes up business opportunities, and obstructs the national development.

In order to promote the spectrum management policies to be in line with the development of technology at the international level and adequately meet the continuously growing demand for telecommunications, the policies and laws in relation to spectrum management causing the aforementioned restrictions, therefore, should be well improved urgently.

METHODS OF SPECTRUM MANAGEMENT

1. USING THE LOST OPPORTUNITY-COST COMPENSATION APPROACH

The opportunity-cost compensation approach or the incentive-based approach uses the market mechanism in spectrum management through compensating the lost opportunity costs for owners of spectrum usage rights so that they can refarm the spectrum for other higher-valued economical activities. This approach aims at supplying a greater amount of spectrum for wireless broadband services and has been considered the best approach so far because it allows the spectrum sharing between platforms and can give rise to telecommunications innovations.

2. PUTTING THE DIGITAL DIVIDEND SPECTRUM IN THE 700 MHZ BAND INTO PRACTICAL USE

Based on the agreement at the World Radiocomminication Conference (WRC-12) made in February, 2012, the digital dividend in the 700 MHz band left over from the digital switchover will be used in wireless broadband services by 2015, possibly in the Long-Term Evolution (LTE) networks.

3. TECHNOLOGY-NEUTRAL SPECTRUM LICENSING

Formerly, the method of spectrum allocation for LTE networks varies among different countries worldwide. One-fifth of all countries in the world have issued technology-neutral licenses, where the type of technology is unrestricted, so that operators can put any technology into use.

CONCLUSION

In this paper, the proposed spectrum management strategies are introduced, both long-term and short-term. Some countries base on related laws which determines that spectrum allocation must be made only through auctions, including the non-transferrable spectrum usage rights conferring upon individuals to exclusively use spectrum are considered the challenges in need of solutions to handle such expansion. In other words, the related sectors should arrive at some solutions to these restrictions so as to manage spectrum effectively through studying further domestic average spectrum demands so that the data can be used to draw up distinct plans, promoting the use of innovations appropriately, supporting the use of shared spectrum, including revising the law provisions that cause restrictions on spectrum allocation so as to make the best use of spectrum to yield public benefits. The analyses and suggestions on spectrum management in this research are considered important factors stimulating the growth in the national economy and eventually taking part in narrowing social gaps.

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