

# COLLECTIVE USES OF SPECTRUM - PROS AND CONS

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## Abstract

The paper provides a literature review of collective use of spectrum (CUS) by consolidating the various perspectives from relevant literatures and the result of the public consultation from the Radio Spectrum Policy Group (RSPG) on November 19, 2008. The paper provides an overview of spectrum management and spectrum assignment approaches plus an elaborate of the advantages and disadvantages of CUS. In addition, further implementation issues are the frequency assignment and the amount of spectrum for CUS.

## Keywords

Spectrum management, mobile broadband, collective use

## 1 INTRODUCTION

Nowadays, telecommunication devices and services have become the mandatory tools in human daily lives both in the business and home uses. Especially, the wireless technology, increasing mobility, is the key driver for move the services to users, anywhere and anytime.

The wireless technology uses spectrum as a media to communicate from one to another. To assign the spectrum to specific services has three approaches – command and control, market based approach and spectrum common or collective use of spectrum (CUS). There are the advantages and disadvantages using each approach founded in this paper especially the CUS.

Moreover, there are 4 literatures and one result of public consultation on CUS from the Radio Spectrum Policy Group (RSPG) in the discussion. The discussion consists of the advantages and disadvantages of CUS and the implication of the use of CUS. Likewise, there are 3 concerns including the suitable frequency, the amount of spectrum and how to implement the technical aspect when CUS will be implemented. The paper will start with the overview of spectrum management, follow by the advantage and disadvantage of the use of CUS and end with consideration issues of CUS implementation.

## 2 PRINCIPLE OF SPECTRUM MANAGEMNET

It has been known that spectrum is telecommunication resources, which could be used in various purposes and the demand is continuously increasing. Especially when telecommunication is one part of daily life, it is a tools to communicate anywhere and anytime to response to their needs.

Spectrum is the electromagnetic wave, composing both electric and magnetic field that can be characterized as properties of light and particle. It can also be named as radio or radio wave or radio frequency or frequency. Usable spectrum is created by human. Sometime spectrum can be treated as national resources.

Spectrum by itself is non-depletable resources but limited in some constraint i.e. the same frequency, same technique cannot be used at the same time and same area. On the other hand, it is re-usable which is divided by frequency and subdivide by time, angle, polarisation, geography and use. The usable spectrum ranges from 9 kHz to 1000 GHz, which cannot be controlled its transmission at the borderline of each country because of its nature. The usefulness of spectrum services can be found nowadays not only in telecommunications services,

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mainly fixed service and mobile service, but also in broadcasting service, satellite service, maritime service, aeronautical service etc.

It has been known that spectrum is telecommunication resources, which could be used in various purposes and the demand is continuously increasing. Especially when telecommunication is one part of daily life, it is a tool to communicate anywhere and anytime to response to their needs.

## **2.1 Overviews**

Analogy of spectrum is similar to a road to carry all traffics from one place to another. It needs to have rules or regulations to control the use of each application to prevent disorder and harmful interference. In addition, proper spectrum management can lead to maximize the use of spectrum by allowing users as much as possible while the interferences are manageable.

Regarding the propagation characteristic of spectrum, there are three levels of spectrum managements which are allocation, allotment and assignment. The allocation and allotment are done at international level and assignment is done at national level. The management at international level has been done by the International Telecommunications Union (ITU), the United Nations specialized agency, by issuing the Radio Regulations (RR) via World Radiocommunication Conference (WRC) to harmonise the allocation of frequency band to the radiocommunication services.

In addition, harmonisation can also be done at regional level. The active regional organisations are Asia Pacific Telecommunity (APT), European Conference of Postal and Telecommunications (CEPT), Inter-American Telecommunication Commission (CITEL), African group and Arabic group. They help consolidate and compromise different ideas within and across regions.

Assignment is done at national level and the mode of assignments are varies from country to country. Spectrum may be assigned by administrator, national regulatory agency (NRA) or relevant ministry depending on laws of each country. Before spectrum will be assigned, the competence authority normally check the availability of spectrum, the existing users, the related regulation both national and international and suitable technical characteristics imposing on the use of spectrum and radiocommunication equipment. However, all obligations imposed by authority must comply with the RR in order to avoid harmful interference and to keep priority to claim from interfering country. Within their territory, the regulators have the right to manage the spectrum by their own authority, but not interfere with neighbouring countries. Setting up the coordination and cooperation with neighbour countries will help to manage the interferences.

There are three typical approaches of assigning spectrum that are command-and-control, market-based and spectrum common approach. Briefly details of each approach are described below.

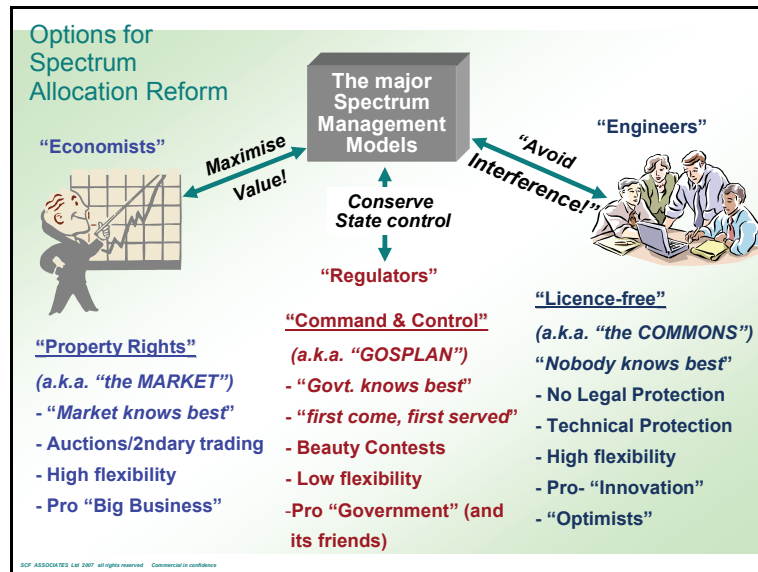


Figure 1: Options for Spectrum Assignment [3]

## 2.2 Command and control

Initially, spectrum was assigned by command-and-control or administrative approach in which competence authority, mostly government, use discretion power to grant an exclusive right of using some frequency band to assignees with conditions. These conditions, mainly for the purpose of avoiding harmful interference, include power limitation, antenna specification and other technical requirements of radiocommunication equipments. Under this approach, basically, spectrum is assigned on first come, first serve basis. Although, it is not complicated process, it is always raised the issue of transparency. Mostly, if spectrum usage is requested by government agencies, they will be assigned easily.

## 2.3 Market-based mechanism

Technology development together with spectrum demand increased make spectrum become scarcity. Since then, market-based approach has been introduced in many countries because, under this approach, it is believed that market knows the best. Mostly, spectrum will be assigned by using auction or secondary trading scheme. This approach creates more flexibility for both regulators and operators to manage the spectrum and make the process more transparent than command-and-control. The well-known auction was the 3G auction in the UK in April 2000. It was the largest auction during that year in which government gained a very big amount of money from BT. However, after BT had won spectrum auction, the business was not commercially viable and, thereafter, spectrum was sold to O2. Although, the market-based approach can maximize spectrum efficiency, in some cases, it can be created spectrum hunting problem by big companies. As a result, market will be monopolized if regulator does not have proper competition policy.

## 2.4 Spectrum commons

The current approach of spectrum assignment is focused on spectrum common in which everyone share common use under the same frequency and some constraints without paying any fees for spectrum usage. Spectrum commons also be known as unlicensed band, collective use or licensed exempted. This approach is believed that nobody knows the best. However, regulator can prevent interference under in spectrum commons scheme by issuing technical specification on the equipments including the frequency, power limitation, antenna gain, type of modulation etc. Nevertheless, services under the spectrum commons cannot claim protection because spectrum common is open for anyone to use with any applications under the given limitation. The good example for spectrum common is Wireless Fidelity (Wi-Fi), Radio Frequency Identification (RFID) and short-range device (lower power devices).

<sup>3</sup> GEISS A., EC DG InfoSoc, B4.

The difference between market-based which assignee has properties right over their spectrum and spectrum common are explained by [BENKLER 2006]. He explains those two schemes as “I can buy an easement from my neighbour to reach a nearby river, or I can walk around her property using the public road that makes up our transportation commons”.

### 3 COLLECTIVE USED OF SPECTRUM REVIEWS

This section will discuss the views from literatures [4] and one result on public consultation of November 19, 2009 [5] from the Radio Spectrum Policy Group by grouping the relevant idea of CUS and then discussed and analyzed.

#### 3.1 Pros and Cons for CUS?

| Cons   | Pros   |
|--|--|
| Irreversible   | Reduce the barrier to entry                                    |
| Complicated to model                                 | Lower administrative cost                                      |
| Lack of innovation if sharing with licensed services | Lower social cost  |
| No legal right to complain for interference          | Create innovation and stimulate the demand for the new service |
| Congestion and limited quality of service            | Suitable for smaller user or low density area                  |

**Table 1: Pros and Cons of CUS**

Table 1 shows a summary of the advantages and disadvantages of CUS which will be discussed more detail as following section.

#### 3.2 Irreversible

Once the regulator or administrator assigned one specific frequency band with some certain conditions for licensed exemption or unlicensed spectrum, all people can use it as public goods. The equipment will spread out everywhere. The good sample is Wi-Fi equipment, at least most of the laptop included Wi-Fi chip set and the Wi-Fi access point could be anywhere from the individual place to the public area such as airport, trains station, university, Wi-Fi hot spot in the hotel, department store etc.

If the regulator would like to get this frequency back in order to reform for other users or services, it will be much more difficulties because the equipment could be placed everywhere and it might take a long time to clear all of them in order to clear this band. For example, if the band of 2400 – 2500 MHz, which already used for Wi-Fi, Bluetooth and other short range devices, is considered to be reforming for new services i.e. cellular mobile network, all of those equipment have to be stopped transmitting the signal or stopping using them and

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<sup>4</sup> The literatures are CAVE M., DOYLE., C, WEBB, W., ‘Essential of Modern Spectrum Management’, Cambridge University Press, 2007., CHADUC J-M., POGOREL G., ‘The Radio Spectrum: Managing a Strategic Resource’, Wiley 2008., MARKS, P. and WILLIAMSON, B., ‘Spectrum Allocation, Spectrum Commons and Public Goods: the Role of Market’, COMMUNICATION & STRATEGIES, no.67, 3<sup>rd</sup> quarter 2007, p.65-84 and TONGE G., VRIES P., ‘The Role of License-Exemption in Spectrum Reform’, COMMUNICATION & STRATEGIES, no.67, 3<sup>rd</sup> quarter 2007, p.85-106.

<sup>5</sup> The public consultation on the draft RSPG opinion on “Aspect of a European Approach to Collective Use of Spectrum” was posted on June 10, 2008 and closed on September 29, 2008. There are 9 respondents including ARD-ZDF, Deutsche Telecom/T-Mobile, EICTA, GSMA Europe, Metil Telecom consultants, Microsoft, Telefónica, PWMS manufacturer Group & Delft University of Technology. The result of this public consultation was posted on November 19, 2008

bring them back in order to ensure the new service will not get the interference from them and becoming chaotic situation.

### **3.3 Complicated to model**

The main equipment using CUS is short range devices or low power devices, which have many applications i.e. garage door opener, radio frequency identification (RFID) or tag or new form of barcode, Bluetooth devices such as wireless key board and mouse, small talk or wireless cabling, and Wi-Fi equipment. The development of wireless technology under low power devices will be continuously all time and have new application or new product at least every year.

To model or forecast the demand for CUS especially in the period of five year or more will be challenged. Thus, the changing application and the varieties of services will be added during the time of forecast as the innovation will effect to the accuracy of model. Therefore the prediction of CUS will be more difficult than other spectrum assignment in the long run.

### **3.4 Lack of innovation if sharing with licensed services**

Normally, when the regulators assigned the frequency to their licensee, the appropriate constraint will be imposed such as the technical specification of the transmitter and receiver, the height of the transmitting station, the modulation type, the level of transmitter power etc. After that, the regulator, under some circumstances, makes CUS to co-use or share with the licensed services. The regulator will put more constrains to CUS to ensure that use will not interfere to the licensed services. This sharing will obstruct the innovation of the application or service both licensed and CUS because if they would like to try the new characteristic of the new application will be limited to the prior constraint. More likely, the extension of CUS less than 30 GHz will reduce the sharing between the licensed services.

However, there are some solutions to solve the interferences problem between the licensed services and CUS by implement the appropriate framework including the distance, the level of power, the part of spectrum, the type of usage and technology (especially cognitive technology).

### **3.5 No legal right to complain for interference**

Generally, after the regulator give one specific frequency under the CUS as public use. All applications can be used under the certain constraints. All users cannot complain to other users or licensed user when the interference occurs. This concept is called as the secondary services which the users do not have the right to complain for interference. That means the users have their own risk to use the equipment under CUS.

For example, there are many people use Bluetooth earphone connecting their mobile phone. When the capacity is fully occupied, the mobile phone cannot connect to the Bluetooth earphones because there is no vacant channel. The more users, the more congestion will happen. Other example, the garage door opener, if their neighbour has the same model, when they press the bottom, all nearby garage door will open unavoidably. The users cannot complain to anyone.

### **3.6 Congestion and limited quality of service**

The use of devices under CUS, generally, has some limit in terms of the service area because of the low power devices. The common problem of congestion usually happens when all users can use all applications at the same time and effects quality of services. The limited quality of service will vary from the high level, when few people use at the same time, to the poor level or might be not working when there is the heavy usage of this band. For instance, in the beginning of the conference, a few participants logon to the Wi-Fi network, the system works smoothly. However, when all participants try to access Wi-Fi network at the same time, they system will be overloaded. The network will be congested and might collapse at the end.

The use of CUS in the lower band below 30 GHz with other services might create the congestion of the existing usage of spectrum and will cause the poor quality of service.

On the other hand, the quality of service can be improved by combination of licensed services and CUS which might be improved the utilisation of spectrum more efficient such as introducing the cognitive devices in the guard band or interleave channel – spacing between transmitting or receiving channel. Moreover, the

development of the relevant standard of CUS will reduce the congestion, improve the quality of service and spectrum efficiency.

### **3.7 Reduce the barrier to entry**

When the regulator assigns a specific frequency under the CUS, all people can access and use the frequency equally. They do not pay the licensed fee or frequency access fee. They only pay for the devices which is a minimal amount of money. This is a crucial advantage of CUS. Moreover, the new entrant or new players can easier get into the market and launch their services or products in order to compete with incumbent or existing operator. That means the barrier to entry into the market has been reduced. The market under CUS will have many providers and have a lot of applications for users. The market becomes more competitive and the users have many choices to choose.

Furthermore, after the regulator announced one specific frequency band with the certain constraints, the manufacturer, who produce the equipment will have certainty to produce their new products to the market. This announcement will reduce the risk of the manufactures in order to create the equipment. If the specific frequency band can be used in other countries - regional or worldwide, the manufacture will have an economy of scale to produce the cheaper devices. For example, the price of Wi-Fi products becomes cheaper.

### **3.8 Lower administrative cost**

Under the CUS, the administrator or regulator have a few work to do when compare to other frequency assignment methods – command and control, market based approach. The regulatory only defines the specific frequency band, the amount of bandwidth and the usage constraints in term of the standardisation of the equipment.

In contrast, if the regulator uses command and control or market base approach for frequency assignment, the regulator has more activities to do, for example, defining the property right, coordinating the existing users, setting the dispute resolution etc. Thus, the administrator cost under CUS is cheaper than other spectrum assignment methods because there are a few activities for regulator to do.

### **3.9 Lower social cost**

The society will benefit the use of spectrum under CUS in many ways. First, without paying the spectrum access fee or frequency usage fee, the operators will get into the market easier thus there will be a lot of player and a lot of competition so that means there are many choices for consumer to select the best for them. After the regulator assigned the specific band under CUS, the manufacturers will have the certainty to produce the equipment. Moreover, if the band can be use regional or worldwide use, the manufacturer will provide the cheaper and better devices to the market.

Second, if the devices can be used regionally or worldwide, the flow or movement of the devices will come across the border of each country and become globally circulation i.e. GSM mobile phone roaming. Besides that, the compatible standard will eliminate the harmful interferences. However, if the devices cannot be use globally, the global circulation will not occur. For example, the low per FM micro transmitter and the ultra wide band equipment (UWB) which widely use in USA but it is illegal in EU.

### **3.10 Create innovation and stimulate the demand for the new service**

The general concept of usage under CUS is to let everyone use many applications and many services in order to share the spectrum within the acceptable level of interference and certain quality of service. This usage will increase the spectrum more efficient than other spectrum assignment approaches.

Moreover, the demand of new applications will increase rapidly. This demand will drive the innovator to create the new product to the market. The competition in the innovation under CUS will become extremely wonderful for the creator to generate any application with any technology to response to the demand.

How make it happen will depend on the decision of the regulator. The regulator should remove all unnecessary constraint under the CUS, only keep the exception for the safety of life and prioritize services. The restriction under CUS should be more flexible, generic and broad categories of devices such as only the maximum power. This will open to anyone to create the new applications for the users.

### 3.11 Suitable for smaller user or low density area

The use of CUS should be suitable for the smaller user. If there are more users to use, it's possible to create more congestion. Furthermore, the pilot project or trail test under CUS for the new frequency should be done in the low density areas in order to avoid the harmful interference to other existing neighbouring services.

However, the developments of the wireless technology – cognitive radio, software define radio, etc. will improve the sharing between the existing services and eliminate the congestion thus all users will enjoy using the application in the near future.

### 3.12 Implication from Pros and Cons

The discussion regarding the advantage and disadvantage of CUS could be categorised into the SWOT analysis which shown the strength, weakness, opportunity and threat in the following table.

|   |  |
|---|--|
| <p><b>Strength</b></p> <ul style="list-style-type: none"> <li>-create innovation</li> </ul>   | <p><b>Weakness</b></p> <ul style="list-style-type: none"> <li>- complicated to model</li> <li>- congestion and limited quality of service</li> </ul>       |
| <p><b>Opportunity</b></p> <ul style="list-style-type: none"> <li>- reduce barrier to entry</li> <li>- lowering administrative cost</li> <li>- lowering social cost</li> <li>- stimulate the demand</li> </ul> | <p><b>Threat</b></p> <ul style="list-style-type: none"> <li>- irreversibility</li> <li>- lack of innovation when sharing with licensed services</li> </ul> |

**Table 2: SWOT analysis of CUS**

The CUS has a major strength to encourage the innovators to create the innovation because the concept of the CUS is to let all technologies, all services and all applications to share the spectrum at the same time. This strength will create the good atmosphere as opportunities.

Furthermore, the CUS will create the certainty for the manufacturer and stimulate the demand of the user. Once the manufacturers have a certainty to produce the devices, the manufacturers [6] will develop the devices and supply them to the market. On the new comers view's point, the CUS will reduce the barrier to entry because they will not pay the licensed fee or spectrum access fee. This will make them easier to get into the market and then the market become more competitive. The CUS will provide the opportunity for the final users to have more choices to select applications, services, operators and devices. Moreover, if the market becomes competitive, the users will have better and cheaper devices. The other opportunity of CUS is lowering the cost of administrator or regulator to regulate the market. The regulator has to set the standard of the devices in term of ex-ante regulation. The standard of devices could be only the frequency, the maximum power and the general safety standard.

In contrast, the CUS has a weakness when the regulator would like to analysis the cost benefit of the CUS. It is complicated model to estimate the demand in the long run because the technology has been changed rapidly. Moreover, the other weakness of CUS is the congestion and limited quality of service. This weakness will be occurred when many users use the devices in the same place at the same time.

Unfortunately, the CUS has a big threat when the spectrum already assigned for public use. It's irreversible or hardly to reform [7] for the new services. For instance, if the regulator would like to reform the 2.4 GHz band – Wi-Fi band, the regulators have to recall all Wi-Fi devices where they are spread over the country and might take a long time to clear this band. The last threat of CUS is the lack of innovation while sharing with licensed service. Because both CUS and licensed service will have the constraint to use of devices in order to avoid the harmful interference, they will have less opportunity to develop the use of their spectrum. Luckily, this threat and the weakness of congestion and limited quality of service can be solved by the development of the new technology and relevant standard including the software defined radio and cognitive radio.

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<sup>6</sup> The manufacturer and the innovator could be the same person.

<sup>7</sup> The reforming of spectrum is the process of recalling spectrum from the existing services or users and re-assigning to the new services or users.

| Advantage                            |                                     | Disadvantage                     |
|--------------------------------------|-------------------------------------|----------------------------------|
| <b>Innovator</b><br>New applications | <b>New Comer</b><br>No spectrum fee | <b>Incumbent</b><br>interference |
| <b>Manufacturer</b><br>Certainty     | <b>Regulator</b><br>Low admin cost  | irreversible                     |
|                                      |                                     | Complicate model                 |
| <b>Final User</b>                    |                                     |                                  |
| Low cost/better devices              | Many choices                        | Congestion Limited QoS           |

**Figure 2: Stake Holder of CUS**

Figure 2 shows the stakeholders of CUS and the summary of advantage and disadvantage of CUS. There is only one weakness and one threat of CUS, which cannot be solved by the development of new technology.

From the discussion of SWOT analysis, the CUS have more concrete strength and opportunity than the weakness and threat which some of them can be solved by the development of new technology and relevant standard. However, there is some risk of the maturity of new technology, which the regulator should be considered.

In general, depending on the objective of the use of spectrum, which varies from country to country, the regulator will select the right approach for spectrum assignment. If the objective of the use of spectrum is for the safety and prioritised service, the CUS could not be the right solution for this objective, however, if there is no specific objective or for general use, the CUS should be selected as the first priority. Furthermore, if the objective of spectrum assignment is to encourage the innovation and stimulate the new demand, the CUS should be put in place.

## 4 CONSIDERATION ISSUES OF CUS IMPLEMENTATION

### 4.1 When is the suitable time for CUS?

To decide when the right time is for CUS, it might be the most the difficult task for regulator to make the decision and come to next question what the indicator is. The possible indicator is the assessment of cost benefit analysis in order to find the net benefit of the economies if the CUS is introduced. The comparison of economic value between the spectrum assignment approaches and the economic value could be measure from the amount of auction from the market.

To conclude, the practical way is to compare the cost benefit analysis in process of impact assessment between implementing and not implementing CUS. These can be measured from the CUS benefit and the cost of denying spectrum to alternative users by other spectrum management approach.

### 4.2 Which frequency is the suitable for CUS?

There is some discussion about this issue among the new comers and the existing user who has obtained other spectrum earlier from auction or licensing. The existing user has concern a lot of the money that they paid for the spectrum and would not like to share with the others, however, the new comer would like to share the entire frequency band as possible.



The possible frequency for CUS are the remaining frequency from the transition of Digital Television called, white space in US, the interleave channel in TV broadcasting or broadband wireless access and the vacant frequency above 40 GHz.

The suitable frequency for CUS should be any frequency which is minimum use or vacant or expected vacant in the future or inefficient or under unutilised frequency. These will depend on the various situations from country to country which have on single solution for this topic.

### **4.3 How to determine the suitable amount of frequency for CUS?**

The amount of spectrum under CUS could be found in two different approaches, top-down model and bottom up model.

The top-down approach is the determination of the overall bandwidth, which is required for CUS across the entire frequency band. For example, if the low power device is the majority of usage in CUS, the estimation of amount of frequency for low power device usage in the next 10 years will be measured – supposed 100 MHz. After that, the regulator has to identify the frequency and free up or release the frequency respected to the need of CUS and review the use of CUS periodically by monitoring the usage of frequency.

The other approach is the bottom-up approach or band-by-band basis. The regulator is selecting the frequency band which will be determined the most likely use of band under CUS and licensed. Next, the regulator should estimate the economic value of the use of that band under CUS and licensed. The regulator should select the approach which maximized economics value. If it's CUS, the regulator should determine the restrictions to be applied.

### **4.4 What is the technical aspect for CUS?**

After selection the frequency and the amount of the spectrum under CUS, the next step will be considered the technical specification for the devices should be imposed. In order to control the use of CUS, the technical characteristics should be done by technical standardisation of the devices, which is set by the regulator depending on the assigned frequency for CUS. Furthermore, the more risk of interference, the more restriction of usage should be implemented in order to share the frequency with the existing services.

Besides that, implementing the band segmentation can use the multiple classes of CUS applications. The low level of power in Ultra Wide Band (UWB) devices can be used across the entire frequency band which there are a lot of concerned from the incumbent to use UWB across the band.

The compatibility studies between the incumbent or existing service and the new entrant should be conducted before the real use of frequency under CUS.

## **5 SUMMARY**

The CUS is one of the spectrum management approaches, which have been set along side with command, and control and market based approach. Furthermore, the concept of CUS is to allow all people to share the spectrum with all applications, all services and all technologies within the some constraints in order to increase spectrum efficiency.

The advantages of CUS are lowering barrier to entry of new entrant, lowering the administration and society cost, creating innovation and stimulating the demand. On the other hand, the main disadvantage of CUS is irreversible after spectrum assignment. When determine the benefit of CUS by comparing the advantages and disadvantages. The CUS itself has more advantages than disadvantages. Moreover, almost disadvantages can be solved by the development of new technology and relevant standard of devices except the irreversible of spectrum once assigned as public use. This issue becomes more political issue than the technical issues. Moreover, the SWOT analysis shows that the CUS has more strength and opportunity than weakness and threat however the risk of the new technology should be taking into account.

Finally, to select the appropriate frequency will be the most difficult task for regulator. The cost benefit analysis will be used in order to determine the economics value of spectrum usage under CUS and other approaches. The result will be information for regulators in order to select the methodology of assignment. The challenge activity of the regulator is to balance the benefit of spectrum usage for all users.

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