「Research on Policy related to 3G Spectrum Re-Auction」

－Final Report－

（English Brief Version）

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1. Introduction

After the launch of 4G network and related application, the need for mobile communication has raised dramatically. As a critical resource, spectrum has been scarcer. According to the model from ITU, it's been predicted that the need for mobile communication would be around 1340-1960MHz for one country. The number is much higher than 600MHz, the amount of spectrum we have released. Considering this, The Ministry of Transportation and Communications has planned to release the spectrum of 1800MHz (C6 block) and 2100MHz. 2100MHz is mainly used to provided 3G services. After the license expires in 2018, the UMTS network is supposed to merge in heterogeneous network and keep serving for mobile phone call. The research team would conduct research for suggestion about the plan, mechanism and reserve price of 1800MHz and 2100MHz.

To enhance the efficiency of spectrum usage, infrastructure sharing and spectrum sharing are adopted gradually worldwide. By sharing, it can also help operator from the massive investment of the properties. The research also focuses on how the regulation evolves with transition of the telecom industry. The issues include the management of spectrum trading, M&A application and the development of new type MVNOs.

New Technique and new business model are main driving force of the telecomm industry. IoT and 5G which are the topic talked for a long time. And now it's the time for construction and even providing business service. New regulation might me a issue to take care. But in the beginning, the research would address more on the technique and the strategy among benchmarking countries. By knowing deeper of the tech, it's more likely to know how to manage and even put restriction on that. At this moment, it's hard to give out a specific regulation suggestion. One thing we need to put emphasis on is that the business model is going diversifying and transitioning. We should catch up instead of using the mechanism before.

2. Plan of 3G Spectrum Re-Auction

According to the announcement from Executive Yuan on 2016/04/18, in response to the 3G license will expire in 2017, 2100MHz band (1920-1980 / 2110-2170MHz) and part of 1800MHz band (1770-1785 / 1865-1880MHz) are planning to release. At the same time, in order to protect the rights of mobile Internet user in remote areas, who win the license this time have to plan how to increase the number and the population coverage of high-speed base stations in remote areas every year.

The 2100MHz band are the 3G license band in Taiwan, so there are four pre-existing license holders, Far EasTone Telecommunications (FET), T STAR, Taiwan Mobile(TWM), Chunghwa Telecom(CHT). Consider the reminding 3G user and the LTE users' needs of CSFB to 3G networks to use the voice services, the 3G spectrum re-auction has a big goal that is to smooth transfer the 3G service. Except the goal of smooth transferring, maintain the fair competition in the market and to facilitate the effective use of spectrum resources also are the goals in this auction. Therefore, we discussed the issue of lot design and spectrum cap in this research.

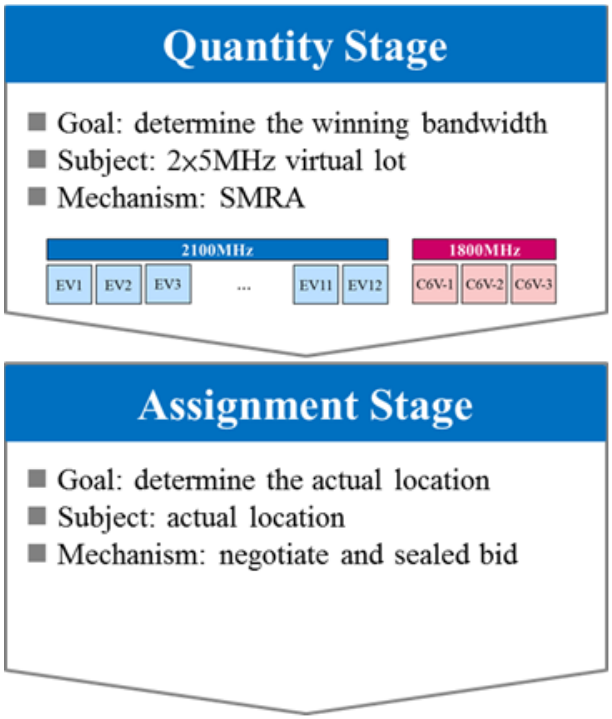
To avoid the recurrence of the vicious competition for the existing location that happened in the first time released 4G license, we suggest using the virtual lot in this auction. In addition, we suggest using the small lot (2×5MHz) in 2100MHz so that bidders can bid lots by their demand. Considering the efficiency of spectrum resources, we suggest setting 2×20MHz as maximum bandwidth to win in 2100MHz. For the maximum bandwidth to win in the auction, we suggest following the past 1/3 principle. For the 1800MHz band, because this is the remaining part, the different lot design will show the different meaning for this auction. Depending on the authority's view of this band and make appropriate planning. Detailed suggestions are shown in the following table.

Issue		Suggestion
Virtual Lot or Actual Lot		To keep the flexibility of the specific actual location, we suggest using the virtual lot in this auction.
Lot Size	2100MHz	To keep the flexibility that let all bidders can base on their needs to bid the bandwidth, we suggest using the small lot (2×5MHz).
	1800MHz	If we follow the last time release 1800MHz using the large lot (2×15MHz), it will be friendlier for the new comer who has no 1800MHz band before this auction. However, if we also use small lot (2×5MHz) in 1800MHz, it will also keep the flexibility that let all bidders can base on their needs to bid the bandwidth, and will be friendlier for the existing license holders in 1800MHz band.
Maximum Bandwidth to Win in Each Band	2100MHz	Considering the long-term efficiency of spectrum utilization and market competition, we suggest setting 2×20MHz as maximum bandwidth to win in 2100MHz.
	1800MHz	Because this time only release 2×15MHz, we suggest not setting the maximum bandwidth to win in 1800MHz.
Maximum Bandwidth to Win in the Auction		We suggest following the past 1/3 principle, and set 2×25MHz as maximum bandwidth to win in the auction.

3. Mechanism of 3G Spectrum Re-Auction

We suggest that this auction use the mechanism of simultaneous multi-round auction (SMRA). This mechanism comes from the Federal Communication Commission (FCC). SMRA is characterized by multiple licenses sold at the same time, and when all licenses have no new bidding price, the auction will end so that all licenses released at the same time.

According to the above discussion, this time will use the virtual lot, so we will have two stages in this auction. First stage is the "Quantity Stage" which bidders place virtual lots, when there are no new prices for two consecutive rounds, the quantity stage ends and move to the second stage. Second stage is the "Assignment Stage" to determine the actual location of the winning lots.



Following we want to discuss more about the Assignment Stage. The principles in Assignment Stage are "maintaining the spectrum continuity" and "maintaining the existing location", let the result of Assignment Stage can minimize the social cost. To fulfill the two principles, we suggest the following steps to conduct in the Assignment Stage for 2100MHz.

Step 1: Determine the order of location assignment

Rule 1: The order is arranged by the bidders' winning quantities in descending

order. If there are some bidders have the same winning quantities, and then follow Rule 2.

Rule 2: The order is arranged by the bidders' existing quantities in descending order. If there are some bidders have the same existing quantities, and then determine in random.

Step 2: Determine the location by the order of location assignment

(1) Determine the location whose order is 1, basically the location assigned should make sure the left side and right side can accommodate the minimum quantities of other bidders.

(2) Use the same principle to determine the location that has the next order, if there are different ways to assign the location, keep every situation.

(3) Repeat the (2), until determining all bidders' location.

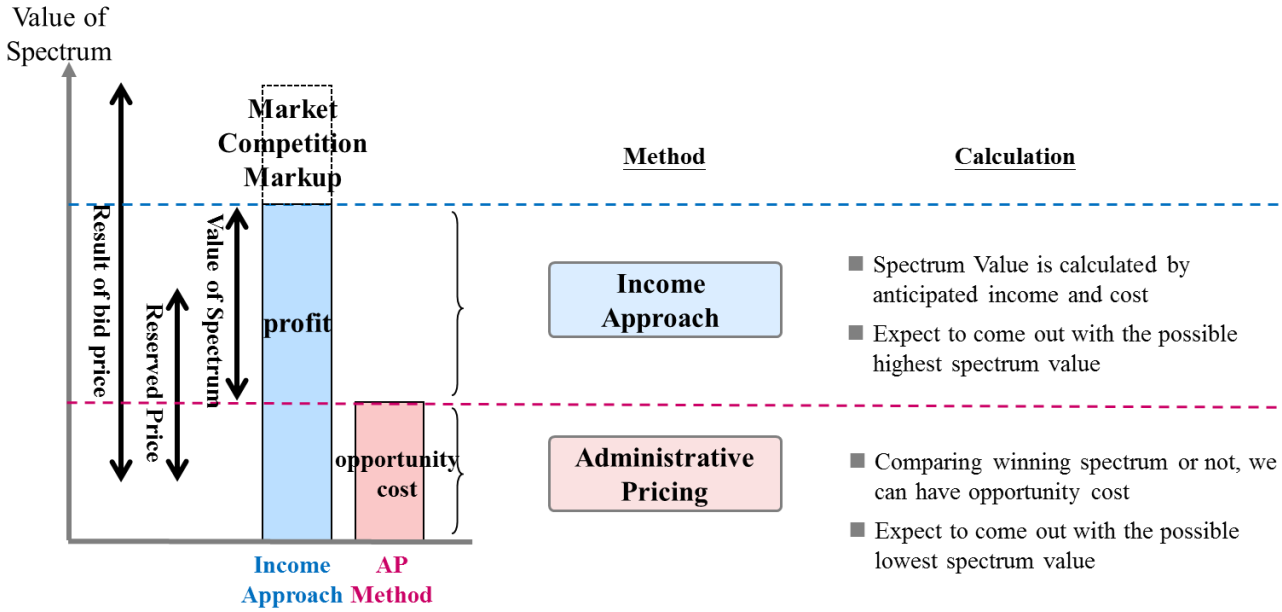
If there are several situations meet both "the spectrum continuity" and "the existing location maintained", we suggest that the winning bidders can negotiate between these situations or propose a new situation. However, if the location situation cannot commit by all winning bidders, we suggest conducting a onetime sealed bid that let winning bidders to express their preference for their own location and choose the largest bidding price set.

The Assignment Stage in 1800MHz is simpler than in 2100MHz. It also should follow the continuity principle, and let winning bidders negotiate first, conduct onetime sealed bid when negotiation fails.

In this research, we also discuss about the eligibility point, withdrawal, and the information disclosure. The eligibility point is using to speed up the auction. However, we suggest that introducing this mechanism should give bidders practice to understand the rules and results with eligibility point. We suggest not to open the withdraw option, because there seems no significant complementary relationship between the lots in this auction. We agree to disclosure more detailed information (bidding price by each bidder, etc.) every round. However, even if the auctioneer does not disclosure the bidder information round by round, the bidder information should be published after auction.

4. Valuation of 3G Re-Auction Spectrum

Deciding the reserved price is key issue in this research. Formerly, it's mostly account on benchmarking method. But sometimes it's hard to make adjustment based on the difference of countries. This time, research team focuses more on income approach. The value of spectrum is calculated by anticipated income and cost which is the amount operator might be willing to pay. By this method, it is expected to come out with the possible highest spectrum value. On the other hand, we also adopt administrative pricing method to calculate the value of 2100MHz spectrum. This method calculates the opportunity cost. The cost comes from the difference of cost they winning the spectrum or not. By administrative pricing method, it is expected to come out with the possible lowest spectrum value.



The Income approach is conducted by two steps. The first step is to estimate the bid price. Taking the trend of telecommunication market into consideration, we use Income Approach and Administrative Pricing Method to calculate the value of spectrum first. Then we subtract spectrum usage fee from total value of spectrum to have estimation of bid price. The second step is to estimate the reserved price. We set a discount rate relating to the anticipated round of bidding. Then we multiply bid price by discount rate to estimate reserved price.

Step 1:

Estimation of bid price

- Taking the trend of telecommunication market into consideration, we use Income Approach and Administrative Pricing Method to calculate the value of spectrum
- Subtract spectrum usage fee from total value of spectrum to have estimation of bid price

Estimation of bid price = **Value of Spectrum** − **Spectrum Usage Fee**

Step 2:

Estimation of reserved price

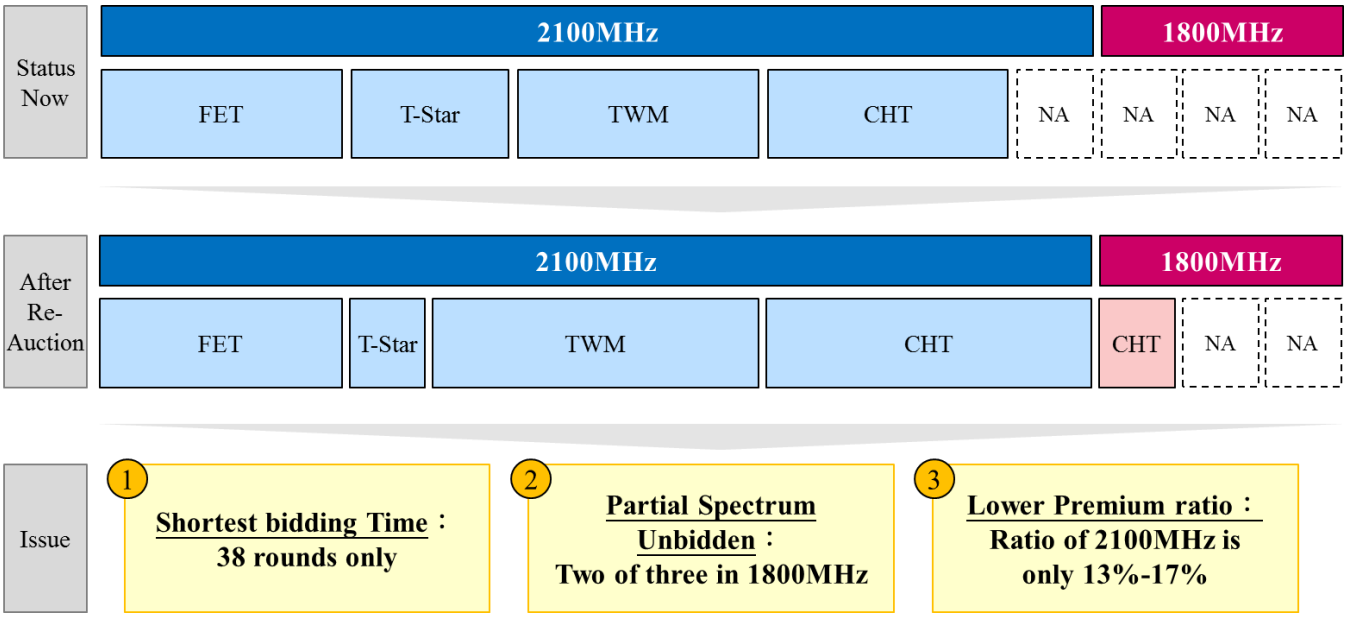
- Discount rate is set related to the anticipated round of bidding
- Estimation of bid price multiply by discount rate equals reserve price

Theoretical reserve price = **Estimation of bid price** × **Discount Rate**

5. Analysis of 3G Spectrum Re-Auction Result

The auction finished in November, 2017. The main target of this auction is to let the original spectrum holder could continue their service in 2100MHz spectrum. From this point of view, we found that FET, T-star, TWM and CHT did get part of their original spectrum after re-auction. It shows the success of the mechanism designed. It mainly contributes to virtual lot and the small size of lot design. Following the virtual lot design, the actual lot location is set based on the rule of continuity of spectrum and the original location first rule. So if the original spectrum holder did buy spectrum in re-auction. It is basically promised to get partial of their original spectrum.

Three issues we found worth to discuss. First one is that the bidding duration is quite short. It cost only 38 rounds to finish. The second one is the part of 1800MHz spectrum is unbidden. And the last one is that the premium ratio is lower than the previous auction of both 1800MHz and 2100MHz spectrum auction. We thought that the main reasons come from two parts. The virtual lot design made this auction procedure more efficient. Operator would only bid on their need. Not too much tactic bidding is needed to consider this time. The reserved price is set at a level could possibly thought to be a little bit high. But in our opinion, it also shortens the time needed for auction. We would like to take it as sign of efficiency. You could see that operators still competed in 2100MHz. It means the reserved price was still higher than the value of spectrum they have estimated. For 1800MHz, we knew two blocks had no buyer. The main reason is that this C6 block is auctioned dependently from C1-C5 block in 1800MHz. It restricted the interest of operators FET and TWM who had spectrum in 1800MHz already. The only candidate to enter 1800MHz biding is APTG. Should we need to set a reserved price that is specially designed for one specific operator? We chose to set the reserved price at a level it should have. If operator cannot use the spectrum efficiently, then it would not able to pay the price. This is what we thought about the meaning of reserved price.



Issue

1. **Shortest bidding Time：38 rounds only**
2. **Partial Spectrum Unbidden：Two of three in 1800MHz**
3. **Lower Premium ratio：Ratio of 2100MHz is only 13%-17%**

6. Benchmarking of spectrum release

In this research, we study the spectrum release cases of 7 countries, including Hong Kong (2014), Australia (2015), Germany (2015), Singapore (2016), South Korea (2016), United State (2016-2017) and United Kingdom (TBD). Most of these cases are released for 4G capacity band. Based on the unique mobile environment in each country, the setting of spectrum cap and the plan of priority are difference in those cases. The following shows spectrum release cases after 2016, we can find that the generic lot and small lot are adopted in most cases, which has used in 3rd 4G license release in Taiwan this year. In addition, because of the simple rule in SMRA, SMRA are used by many countries to facilitate the auction. For the next license release, probably the 5G license, we suggest follow the 2.3GHz and 3.4GHz spectrum release in United Kingdom continuously to get some new idea in the future.

Country	Singapore	South Korea	United State	United Kingdom
Year	2016	2016	2016-2017	To Be Decided
Band Released	700Mz, 900MHz, 2.3GHz, 2.5GHz	700MHz, 1800MHz, 2100MHz, 2.6GHz	600MHz	2.3GH, 3.4GHz
Auction Mechanism	New Player Stage: SMRA; General Stage: Clock-Plus	Principal Stage: SMRA; Assignment Stage: Sealed Bids	Incentive Auction	SMRA
Lot Design	Generic Lot	Actual Lot	Generic Lot	Generic Lot
Lot Size	900MHz (New Players): 2×10 MHz; 700 & 900MHz: 2 ×5 MHz; 2.3 & 2.5GHz: 5MHz	700MHz & 2.6GHz: 2×10 MHz; 1.8GHz, 2.1GHz, 2.6GHz: 2×20 MHz	2×5 MHz	2.3GHz: 10MHz, 3.4GHz: 5MHz
Spectrum Cap	With New Player: 75MHz; Without New Player: 100MHz	60MHz	No	Which is the controversial point now
Priority	Yes, Pre-existing license holder have priority to get spectrum	No	Reserve 30MHz for operators who are small and meet some conditions	No
Others	-	Auction ended 700MHz lots with nobody bid	Repack the 6MHz broadcast lot into 2×5MHz LTE lot	Pre-existing license holder in 3.4GHz can choose to re-assign into continuous band

7. Research on regulation of Telecomm operator

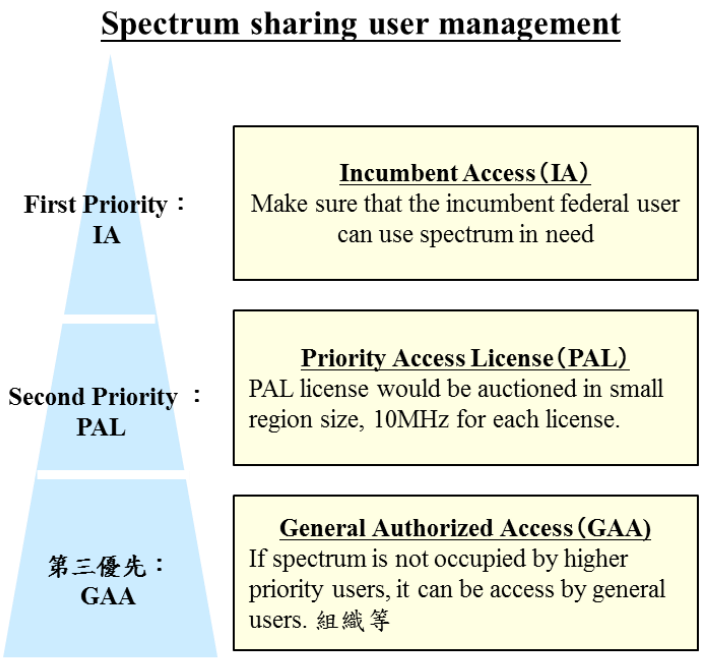
In this paragraph, we would discuss about some regulation relates to telecomm operators. We did some benchmarking work to find out the trend all over the world. Three topics we would discuss here. First one is about the limitation on spectrum amount and transaction. Is there a upper limit of spectrum amount one operator could hold? Should we open the secondary market of spectrum? The second issue is about the sharing of spectrum. We saw some case is happening but not mature enough. But it's one thing we need to keep tracing for spectrum would never be enough. In third issue, we would like to know how the spectrum for emergency used which is called PPDR is planned.

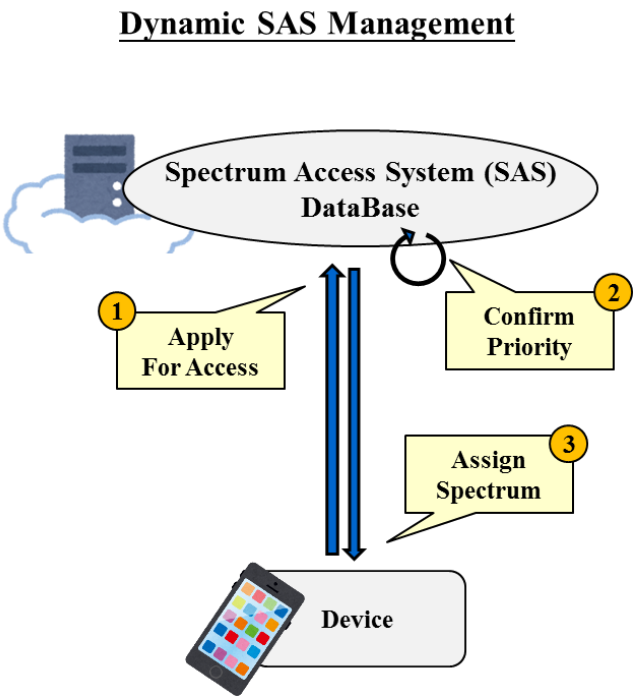
7-1 limitation on spectrum amount and transaction

	US	UK	GE	HK	SG	JP	KR	TW
Main Operator	5	6	3	5	4	3	3	5
How to release spectrum	Auction	Auction	Auction	Auction	Auction	Assigned	Assigned →Auction	Auction
Upper limit of spectrum below 1GHz	1/3	42%	1/3	—	—	—	—	1/3
Upper limit of total spectrum	1/3	37%	X	—	—	—	—	1/3
Spectrum trading	O	O	O	—	O	—	O (no case)	O
Spectru leasing	O	O	O	—	—	—	—	—

7-2 Spectrum Sharing

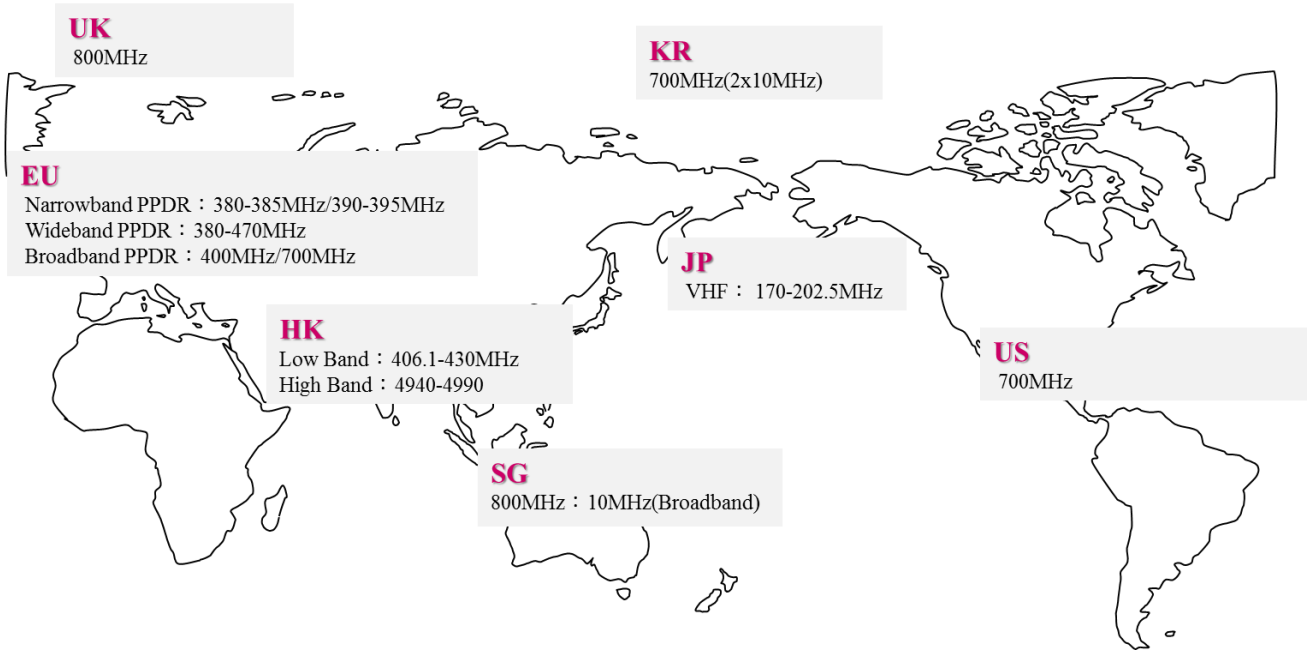
In Japan, they did share spectrum in static way. They separate the usage geographically. Satellite communications already occupy the outdoor usage of 3.5GHz. The IMT usage could still share the spectrum by indoor usage. On the other hand, US and UK share the spectrum dynamically. There would be one database for dynamic spectrum sharing. If one wants to use spectrum, it should ask db to check their identity and assign the spectrum. The users might have different priority to access the spectrum. The incumbent user must be the highest one. And there would be some priority access license for auction. The general user then can use the spectrum when it's not assigned to incumbent user or the user with licenses.





7-3 PPDR

We conclude the spectrum used for PPDR. Most countries would have low band for coverage. Also, they start to think about the use of broadband spectrum for video communication use.

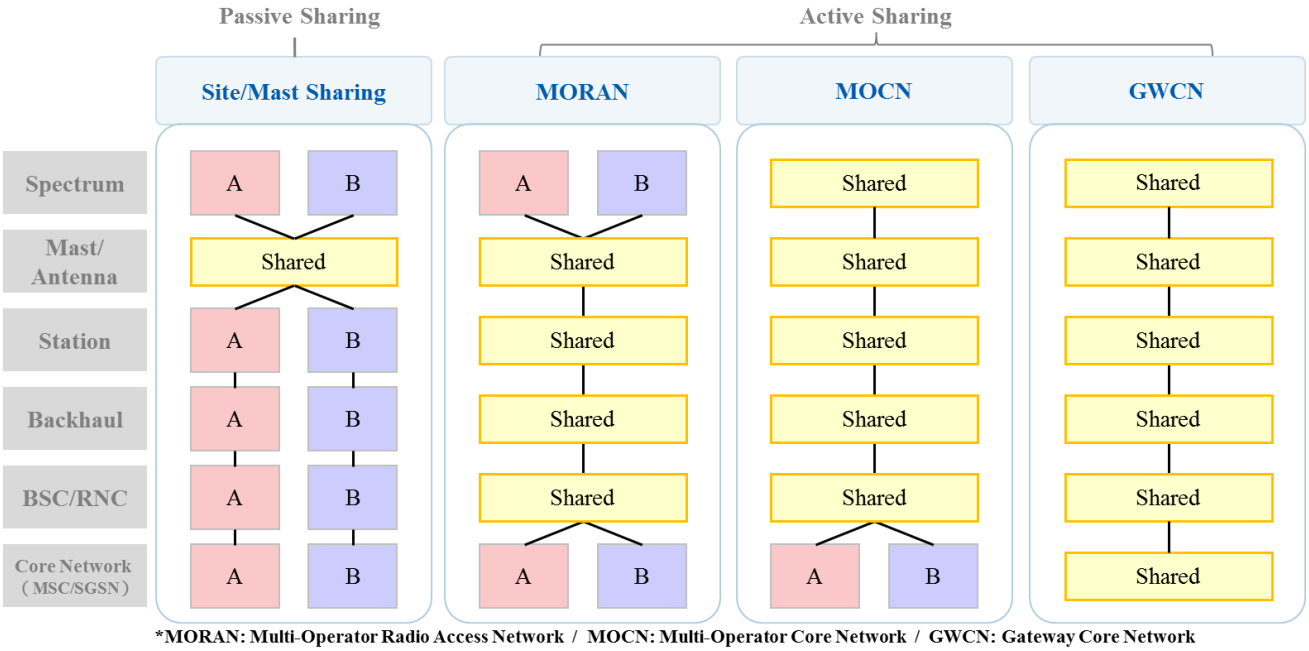


8. Research on cooperation between Telecomm operators

To enhance the efficiency of operating network, operators try to cooperation more closely. There are many ways to cooperate like infrastructure sharing, roaming, MVNO, backhaul rental and M&A. We think infrastructure sharing and MVNO development is especially important for Taiwan and would discuss more in the following paragraph.

8-1 Infrastructure Sharing

There are many ways to share infrastructure. Theoretically, closer the sharing would have less cost on network. But the regulation is different in each country. Some would consider sharing core network as a decreasing influence of market competence. Thus it is prohibited. Take Taiwan for example, site sharing and MORAN is allowed. MOCN and GWCN are not open yet. For the current network among operators, it’s hard to share. Since each operator has their own power and construction strategy. We think the sharing in rural area and adoption of new technology like 5G is more possible. Sharing in rural area could save the money from government while enhance the quality of mobile communication in rural area. We don’t need to have five networks in uneconomic are. One sharing network might be a solution for this. Sharing of 5G network is for shorten the time and cost for adopting new technology. If we want operators to spend less money only on construction, the promotion of sharing in 5G is quite important. And operators expect for this too.



8-2 MVNO

MVNO is not a trendy issue. But new type of MNVO is the topic we want to raise. From the example of Japan, it shows the original MVNO is decreasing by fierce competence. And we already have five MNO operators in Taiwan. Some of them could possibly play as the market competence facilitator. The OTT type and M2M-related MVNO lead the next wave of MVNO. The need of network would be diversified. It's hard for MNO to cover all the needs. To expand the market and fulfill the need, MVNO is the force cannot be ignored.

MVNO Type	Example	Trend	Growth
Operator、ISP	OCN、IIJ、日本通信、Biglobe, So-net、Nifmo	IIJ、日本通信、OCN turn to provide MVNE service	
Retail Store	AEON、BIC CAMERA、Yodobashi Camera	Keep growing. Many vendors use MVNE serivice from IIJ	
OTT	樂天Mobile、LINE、ToneMobile（TSUTAYA）	Most Popular and growing fast. Vendors started to combine telecom service with their own OTT service	
M2M related（ex: car）	TOYOTA、SECOM（Security）	Even the market is growing, it's not necessary to conducted by MVNO. MNO started to have more option in fee plan.	
Sub-Brand of MNO	Y! Mobile、UQMobile（KDDI）	Growing by take advantage of parent company. But it could also contribute to competence between sub-brand and parent company.	

9. Global Development of IoT

There are many IoT standard and techniques come out these year. LoRa and sigfox take advantage of unlicensed spectrum to deduct the cost for providing service. LoRa network is designed as star topology. Devices connect to gateway first. It's gateway need to connect to server. It would be more flexible in LoRa network deployment. Sigfox is specialized in lean protocol design, It could have only 140 message at most per day. And each message only need 12 bytes, no extra control signal is needed. It also means less power consumption for devices. After the expansion of LoRa and Sigfox, 3GPP had NB-IoT and LTE Cat M1(LTE-M) for telecomm operators compete in IoT market.

	LoRa	Sigfox	NB-IoT	LTE Cat M1
Time	2015年	2009年	2016年	2016年
Spectrum Use	EU:433、868MHz US: 915MH	EU: 868MHz US：915MH	Incumbent Spectrum Mainly 700-900MHz	Incumbent Spectrum Mainly 700-900MHz
Bandwidth	125KHz	0.1KHz	200KHz (HD-FDD)	1.4MHz (HD-FDD、FDD、TDD)
Bitrate	300bps~50kbps	100bps	~50kbps	~375Kbps(HD-FDD) ~1Mbps(FDD)
Characte-ristic	• Adopt Star topology. Device connect to gateway first. It's gateway need to connect to server. More Flexible in network deployment.	• Lean protocol Design • 140 message at most per day. Each message only need 12 bytes. No extra control signal needed • Less power consumption for devices	• Will have positioning, multicast, mobility and continuity support function in Rel-14	• Support VoLTE • Support mobility and continuity function

Spectrum might be the first issue to take care of. But we already have 920-925 released for IoT usage. And operators would mainly account on their original spectrum to construct NB-IoT network. It shows no need for more spectrum specifically release for IoT use in short term. For regulation part, we saw that less discussion about regulation now. But one thing is important that, the business model in IoT is totally different from previous 3G or 4G service. The quality of network might also differ from the one served for end user. The regulation might need to be adjusted. We would still keep track on the global trend for providing the latest news.

10. Global Development of 5G

The development of 5G keeps speeding up. 2020 might be a critical milestone for many countries launch commercial network or service. Currently, spectrum standard is crucial for each country. Sub-6GHz might be the first wave. 3.5GHz attract most attention. The spectrum above 6-GHz plays key role in 5G since there's more continuous spectrum left. To reach high speed transmission, spectrum is needed for sure. We think that the global standard for 5G would be clearer after WRC-19. It's reasonable to assume that we could release our first 5G spectrum around 2020.

	Sub-GHz (MHz)	1-6GHz (GHz)	Above-6GHz (GHz)
US	600	3.55-3.7	27.5-28.35、38.6-40、37-38.6、64-71
UK	700	3.4-3.8	24.25-27.5
FR		3.4-3.8	
CN		3.3-3.6, 4.8-5.0	
SG	800	1.5, 3.4-3.6	24.25-29.5, 、31.8-33.4、37-43.5、 45.5-50.2、50.4-52.6、66-76、81-86
JP		3.6-4.2, 4.4-4.9	27.5-29.5
KR		3.4-3.7	28

The mechanism to release 5G spectrum might be different from the auction this time. Lot size for 5G might be bigger since that it's more efficient for one operator to have at least 100MHz continuous spectrum. Other issues like business model and service model are taken into consideration too. So the mechanism needs to be designed with benchmarking and the knowing of industry status in Taiwan. We should be prepared in advance for 5G could be also totally different than 4G generation.

11. Conclusion

The study could be separated into two parts. First one is for the re-auction this year. So we did the analysis by benchmarking and also the domain knowledge we had. We gave some suggestion about the mechanism of auction. Virtual lot and Small size of lot are two main suggestions. Speaking of reserved price of the spectrum, we adopt income approach. Taking the revenue and cost of operators in recent years into consideration, we tried to estimate the precise value of spectrum. And the results showed the estimation was quite close to the one operator had. So the premium ratio is quite low this time. Since the adoption of virtual lot, operator did not need to perform tactical bid. The procedure went fluently. And the adoption of small size of lot also shows the effect. Operators could make bidding based on their needs. FET has won more spectrum before so FET only bid for three lot in 2100MHz spectrum. CHT and TWM bid for four lots to enhance the capacity. While T-star buy only one lot to continue their service.

In the regulation part, we did the benchmarking study on the trend of regulation and development of new technology. Overall the telecomm industry is facing the trend of integration to have more competing power. For regulator, to maintain the competency of the market is key task. Some operators would even apply for M&A. If it hurts the competency of market, regulator could choose to deny or approve of condition. Sharing is another trend in telecomm industry. Spectrum sharing and infrastructure sharing are all developing around the world. Despite the adjustment of laws, regulator also has the responsibility to facilitate the industry. Closer communication and understanding is needed between industry and regulator. For new technology like IoT and 5G, new business model and service model might emerge. New concept of regulation is expected. Keeping track of global trend and development of industry would help to come out a well-designed telecomm regulation environment.