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Technology Neutrality: Interaction between International Mobile Telecommunication and National Spectrum Management Policies

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Technology Neutrality: Interaction between International Mobile Telecommunication and National Spectrum Management Policies*

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Abstract

“The ITU is currently working on one of its most ambitious projects ever: systems standards for third generation mobile telecommunications...coined IMT-2000, it will make it possible to communicate anywhere-anytime”

The fifteenth Plenipotentiary Conference of the International Telecommunication Union, 1998.

The Radio Sector of the ITU (ITU-R) has been involved in two aspects of personal mobile communication systems, namely defining the standards and identifying frequency bands related to these systems under the label of the International Mobile Telecommunication (IMT). This paper has investigated the influence of IMT standardisation activities in the ITU-R on national spectrum management policies with regard to decisions related to technology neutrality and technology selection.

This paper has shown the different views on the importance of being one of the IMT technologies on regulator decision on technology selection, and has also revealed the elements in the IMT process that encourage and discourage more neutrality approach in technology selection. Moreover, different views on the mutual influence between the IMT definitions and 3G and 4G market definitions are highlighted.

Furthermore, this paper has demonstrated how that the IMT spectrum identification has different positive influences on selecting technologies from the IMT family, which is mostly dependent on the country, and has also different positive and negative elements of influence on the tendency towards technology neutrality.

In general, the paper shows that the international spectrum management regime does not prevent adopting technology neutrality, while having different elements of support and opposing regarding regulators' tendency towards technology neutrality.

Paper presented at 26th European regional conference of the International Telecommunications Society, *What next for telecommunications?* 24-27 June, San Lorenzo de El Escorial, Spain

1. Introduction

The rapid growth in wireless services and the increasing demand for mobile broadband have called for re-examining how radio spectrum, a critical component in the delivery of wireless services, is managed. This has inspired several scholars to review the traditional approach to national spectrum management, ‘command and control’, which has been criticised for creating artificial scarcity that is due to inefficient utilisation rather than spectrum shortage (Wellenius and Neto, 2005).

One main element of the command and control is selecting technologies to be deployed by the operators (OECD, 2006). Therefore, alternatives spectrum management approaches to command and control embrace technology neutrality among other measures for reforming national spectrum policies to overcome the deficiencies of command and control (Chaduc and Pogorel, 2008).

At the international level, the ITU-R is the administrative body responsible for managing spectrum matters that have global influence through the ITU-R Radio Regulations and the ITU-R resolutions, recommendations and reports. The ITU-R Radio Regulations (RR) have international treaty status and they are binding for all the ITU-R countries (Maitra, 2004). On the other hand, ITU-R recommendations do not have a legal status similar to the ITU-R RR unless they are incorporated by reference in the RR (McLean Foster & Co., 2013).

The ITU-R has been involved in two aspects of personal mobile communication systems under the label IMT: defining the standards and spectrum identification related to these systems as a response to the lack of interoperability between 2G standards and the need for global roaming. In particular, the ITU-R work on the International Mobile Telecommunication (IMT) standards has resulted in having six and two terrestrial radio interfaces to be part of the IMT-2000 and IMT-Advanced family of standards respectively. In addition, the IMT standardisation process has been associated with identifying spectrum bands by the ITU-R for the use of IMT radio interfaces to enable global roaming.

However, it is not clear how the international activities in the ITU-R related to mobile technologies influence national regulators’ decisions on these technologies. More specifically, while most of the literature that address technology neutrality focus on national circumstances such as market structure and auction design; the influence of IMT standardisation activities in the ITU-R is largely overlooked.

Having said that, the main research question of the paper is decided to be ‘How do the international radio spectrum management regime and national radio spectrum management

policies interact with regard to technology neutrality?’ More specifically, the paper attempts to address four main questions, namely:

1. What is influence of IMT standardisation on technology selection and technology neutrality on the national level?
2. What is influence of IMT standardisation on perspectives regarding mobile technology generation definition?
3. What is influence of IMT standardisation on discrimination between mobile technology generations?
4. What is influence of IMT spectrum identification on technology selection and technology neutrality?

The rest of the paper is organised as follows. The following section explores mobile technology selection on the national level, and Section three addresses the activities related to personal mobile standardisation in the ITU-R. Section four highlights the methodology adopted for this paper. Sections five to eight examine the interaction between the international spectrum management regime and national spectrum management policies in terms of decisions related to technology neutrality and technology selection, influence of the IMT standardisation on the perception on 3G and 4G technologies in terms of generation definition, influence of the IMT standardisation on the discrimination between mobile technology generations on the national level, and influence of IMT spectrum identification on regulator’s decision regarding technology selection and technology neutrality respectively. Section nine concludes.

2. Technology Selection

Technology selection is one of the main elements of any spectrum management approach where selection of technologies could be neutral, restricted to standardised technologies, or selective of specific technologies (Chaduc and Pogorel, 2008). Firstly, standardisation refers to the level of specification of allocated services such as transmitter power, channelization, and interoperability. On the other hand, technology neutrality is defined by Foster (2008) as the minimum applied constrains while ensuring that interference is appropriately addressed. Whittaker (2002) argues that true technology neutrality implies defining conditions without any biased assumptions.

An important element of technology selection is channel planning which accommodates type of channel duplex mode (frequency division duplex (FDD) or time division duplex (TDD)) and the width of the channel (e.g. 10, 20 MHz).

The main advantage of standardisation is that it allows large production scale, which reduces the cost of the equipment. Moreover, benefits of standardisation include avoiding harmful interference and promoting interoperability between terminals and public networks. Anker and Lemstra (2011) argue that national regulator usually prefers to select a standardised technology because it obviates the need for specifying particular technology characteristics as part of the licensing process. The license conditions would instead state that the operator's technology should be of a global standard.

On the other hand, standardisation may lead to lock-in to an inferior standard and delays in the introduction of new equipment (Indepen and Aegis Systems, 2004, London Economics, 2008, Pogorel, 2007). An example of the failure of regulators in selecting the rights technology is the enhanced radio messaging system (ERMES) which was an initiative to create a Europe-wide mobile messaging system that ended with no significant implementation (Cave, 2002).

Technology neutrality has been advocated as part of the spectrum market approach, one of the main alternatives of the command and control (Pogorel, 2007). In such approach it is argued that private operators are more knowledgeable of the market and will choose the optimum service to the consumers (Hazlett, 2001). Applying technology neutrality could be in the form of awarding a new mobile license to any technology the operator would choose or allowing an existing licensee to change the deployed technology.

With regard to the personal mobile telecommunication, there have always been tensions between different technologies. For instance, in the 2G era, there was competition between GSM and CDMA standards, with the former winning in terms of the number of global subscribers (Saugstrup and Henten, 2006, Curwen, 2004). During the 3G era, the most prominent competition was between WCDMA and CDMA2000 1xEV-DO/DV, with the former having a larger number of subscribers (Saugstrup and Henten, 2006). The race for 4G is between the IEEE and 3GPP, which are responsible of WiMAX and the LTE-Advanced respectively. It is argued by some that LTE-Advanced has superior performance in terms of coverage area, bandwidth utilization and data rates (Singh, 2013).

The concept of technology neutrality has emerged with the development of personal mobile telecommunication. Initially, in Europe, for example, the European Commission (EC) enforced the exclusive usage of the 900 MHz and 1800 MHz bands for GSM (Curwen,

2004). In the 3G era, Saugstrup and Henten (2006) suggest that the influence of the policy makers in the technology development has decreased with the liberalization of the telecommunication markets. In particular, the calls for technology neutrality that started in the 1990s when the US government stated that there should be no assumed or required specific technologies. Instead, rules should be technology neutral (Ali, 2009). In Europe, technology neutrality has been one of the guiding principles of regulation of the telecommunications sector (Lovells, 2014). Today technology neutrality is a widely recognized and accepted concept (Ali, 2009).

van der Haar (2007) states the reasons for the emergence of the principle of technology neutrality in the context of the EU. The calls for technology neutrality were motivated by the convergence technologically between different sectors. Accordingly, there were concerns that non-neutrality may cause competitive disadvantages for the different companies operating in the market. The need to address any disadvantages that arise would be in addition to other economic and regulatory rationales such as non-discrimination derived from technology. In addition, technology specific regulation acted as entry barrier that prevents competition between services based on different technologies. (Kamecke and Korber, 2006).

The practice of technology neutrality varies around the world. In Europe, GSM was mandatory for operators (Cowhey et al., 2008) until 2009 when the use of spectrum bands reserved for 2G technologies were opened up to 3G technologies (Bohlin, 2012). Japan took the position that the 2.5 GHz band would be reserved for non IMT-2000 technologies (Sims, 2006), while in Hong Kong the award of a standard specific CDMA 2000 license was announced (Sims, 2007a). In China, the government assigned each of the three operators a particular standard, namely, TD-SCDMA, CDMA 2000 and WCDMA (Newlands, 2009).

3. International Mobile Telecommunication

In general, the ITU has been involved in compatibility of telecommunications standards since its first days to handle the issue of Marconi monopoly (Savage, 1989). In particular, the Marconi company refused to relay messages received from competing operators (Anker and Lemstra, 2011). Later on, the ITU-R did not succeeded to agree on one standard for coloured TV in the 1960s and therefore, three standards were approved (Zacher, 1996). Savage (1989) argues that multiple standards have been viewed by the ITU as a policy of last resort.

With regard to personal mobile communication systems, the ITU-R has been involved in two aspects: defining the standards and frequency identification related to these systems (ITU-R, 2007c). The involvement of the ITU in the standardisation process was mainly in

response to the formulation of several national and regional standards bodies that were perceived as a threat to the role of the ITU in setting international telecommunications standards (Besen and Farrell, 1991). In particular, the lack of interoperability between second generation (2G) mobile standards motivated the ITU-R to become more involved in the standardisation process of mobile systems (ITU, 1998). In addition, it was clear that the mobile market became quite large and more worldwide rather than national or regional (Funk, 1998) which called for a global effort towards a worldwide third generation (3G) standard.

The first step of the ITU standardisation activities on mobile technologies was in the 1980's where the concept of FPLMTS (Future Public Land Mobile Telecommunication System) was discussed in the ITU-R (Formerly International Radio Consultative Committee (CCIR)). That was mainly due to the support of the European countries which seek to have successor to the Global System for Mobile Communications (GSM) system (U.S. Congress Office of Technology Assessment, 1993). More specifically, the ITU-R Task Group 8/1 was formed in 1985 to define a framework for FPLMTS services (Callendar, 1994). FPLMTS was renamed IMT-2000 by the Radiocommunication Assembly (RA) prior to the WARC-97 (ITU, 1997). WARC-92 also adopted resolution 212, providing the general framework for IMT-2000 standards development and system implementation (Leite et al., 1997).

The ITU-R established a procedure for submitting and evaluating the IMT-2000 radio interfaces proposed by the national/regional standardisation bodies (ITU-R, 2010). Following that, the ITU-R invited applicants for IMT-2000 radio transmission technologies in 1997 and ten terrestrial proposals were submitted in 1998 (Engelman, 1998). Among these proposals, five radio interfaces were approved to be part of the IMT-2000 standards: WCDMA (also known as UMTS), CDMA 2000, TD-SCDMA, EDGE, and DECT (ITU-R, 2009). The main key requirements of IMT-2000 were set to provide data rates up to 2 Mbit/s (ITU-R, 1997). A few years later in 2006, the IEEE submitted a proposal to include the WiMAX standard named as IP-OFDMA into the IMT-2000 family of standards (WIMAXForum, 2007). ITU-R RA-07 agreed in October 2007 to officially include WiMAX to the IMT-2000 family (Sims, 2007b).

Regarding 4G standards, the ITU-R announced its invitation for the submission of proposals for candidate radio interface technologies for the terrestrial components of IMT-Advanced in 2008 (ITU, 2008). The main key feature of IMT-Advanced was set to be providing enhanced peak data rates up to 100 Mbit/s for high and 1 Gbit/s for low mobility (ITU-R, 2007a). There were six different proposals containing two main technologies: IEEE (IEEE 802.16m) and 3rd Generation Partnership Project (3GPP) (LTE Release 10) (WP 5D Chairman, 2009). Later, these six proposals were consolidated into the two IMT-Advanced

technologies: LTE-Advanced and WirelessMAN-Advanced (ITU, 2010). These two technology standards were submitted to the RA-12 and were agreed by the ITU-R member states (ITU, 2012). The LTE-Advanced standard was identified as LTE Release 10 and beyond, while the WirelessMAN-Advanced standard was identified as IEEE 802.16m (ITU-R, 2012a). Table 1 below displays a timeline of the ITU-R activities on IMT standardisation.

Year	Standardisation activity
1985	The ITU-R Task Group 8/1 was formed to define a framework for FPLMTS services
1997	The name FPLMTS was renamed IMT-2000
1997	The ITU-R invited applicants for IMT-2000
1998	Ten terrestrial proposals were submitted for IMT-2000
1999	Five radio interfaces were approved to be part of the IMT-2000 standards
2006	The IEEE submitted a proposal to include WiMAX into the IMT-2000
2007	RA-07 agreed to include WiMAX to the IMT-2000 family
2008	The ITU-R announced its invitation for the submission of applicants for IMT-Advanced
2009	Six different proposals containing two main technologies (IEEE (IEEE 802.16m and LTE Release 10) were submitted
2012	The RA-12 approved the two technologies to be part of the IMT-Advanced

Table 1: Timeline of the ITU-R Activities on IMT Standardisation

The IMT standardisation process has been associated with identifying spectrum for the use of IMT standards by the ITU-R. The first step with this regard was when the European countries called for spectrum allocation for FPLMTS in the mobile WARC of 1987 but the issue was postponed until WARC-92. During WARC-92, countries such as the US opposed allocating new frequencies for FPLMTS (U.S. Congress Office of Technology Assessment, 1993). Eventually, the conference identified the bands 1885-2025 MHz and 2110-2200 MHz for countries wishing to implement FPLMTS (ITU, 1992). Table 2 below shows a timeline of the IMT spectrum identification by different WRCs.

WRC	IMT Identified bands
WARC-1992	1885-2025 MHz and 2110-2200 MHz (ITU, 1992)
WRC-2000	806-960 MHz, 1710-1850 MHz, 2500-2690 MHz (ITU-R, 2001a, ITU-R, 2001b)
WRC-2007	450-470 MHz, 698-806/862 MHz, 2.3-2.4 GHz, and 3.4-3.6 GHz (ITU-R, 2007d, ITU-R, 2007b)
WRC-2012	694-790 MHz (ITU-R, 2012b)

Table 2: Timeline of IMT Spectrum Identification

4. Methodology

This section explains the undertaken research strategy in order to examine the interaction between IMT and national spectrum decisions' regarding technology selection and neutrality. In particular, a qualitative methodology is adopted for this paper that utilises an inductive approach where the theory is developed upon the observations or the findings of the research (Bryman and Bell, 2007). The paper is mainly based on primary data collected from fifty-five semi-structured interviews with the main stakeholders from national regulators, mobile industry, ITU-R study groups and working parties.

The second step to conducting the interviews was data reduction which is the process of selecting and simplifying the data included in the interviews transcription (Miles and Huberman, 1994). Data reduction has been achieved in this paper through coding which is defined as breaking data down into component parts which are given names (Bryman and Bell, 2007). Coding is used to links data to ideas and also to find out links between the different ideas (Bazeley, 2007). A software called NVivo was used for that purpose in order to identify the important themes (Bazeley, 2007) where the final form of the transcription of the interviews was imported into NVivo as word files. In order to verify the data coding process, four independent coders were selected to double code some selected interviews.

The third step was data display in order to present the information systematically to drive valid conclusions (Miles and Huberman, 1994). The researcher displayed the collected data after reducing it for several reasons (Miles and Huberman, 1994). Firstly, it is difficult to analyse dispersed data. In addition, the process of drawing conclusions for the readers from data display has much better chances than doing that from extended text. Moreover, data display help discovering new relationship and proposing explanation.

The display type used for this paper is conceptually ordered network display where display is ordered by concepts. While there are several formats for such type of network display, this paper adopts the graphical representation of 'cognitive mapping' which is a causal based mapping technique that is used mainly to represent the subjective world of interviewees (Eden, 2004).

A program called 'decision explorer' was chosen for displaying the data because it was designed specifically to support cognitive mapping (Banxia Software, 2014). There are different features in the 'decision explorer' program that enabled the research to handle the complexity of the maps such as hiding some details and focusing on groups of concepts. One feature that was useful is the ability to have a style for each concept or user defined links. For

reasons of simplicity, the researcher adapted three types of styles for displaying concepts as shown in Figure (1).

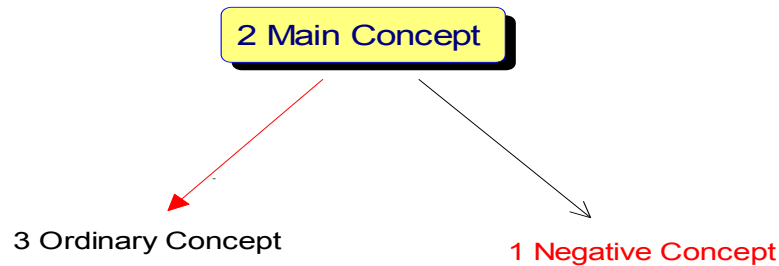


Figure 1: Link and Concept Styles

Concept (1) is called a negative concept where interviewees perceive such concept adversely or unfavourably. Concept (2) is a main or key concept that was identified during the data analysis while concept (3) is a typical or normal concept. The black arrow represents a causal links of being related or leading to. On the other hand, the red arrow with the negative sign implies negative relationship or link (e.g. decreases, negatively influence).

It should be noted that the decision explorer program creates automatic numbering system that does not convey any specific meaning. In order to verify the data display process, four independent mappers were selected to double map some selected topics. The next four sections shall address the paper four questions based on the primary data collected from the interviewees that are involved in the IMT activities at the ITU-R.

5. Influence of IMT Standardisation on Technology Selection and Technology Neutrality

This section addresses the first of the four research questions outlined in Section 2. In particular, it investigates the influence of IMT standardisation on technology selection and technology neutrality on the national level. In general, the interviews revealed that IMT related activities in the ITU-R are not limited to selecting technologies to be part of the IMT family of standards. It also includes interference assessment, spectrum sharing, and channel frequency arrangement, which need agreed international approaches. Moreover, some countries adopted mobile systems other than IMT such as Advanced PHS, which are

described in ITU-R recommendations other than those related to IMT (e.g. ITU-R M.1801). It was also explained that the way Working Party (WP) 5D¹ deal with specific technologies is not exceptional as there are other ITU-R working parties that deal with specific technologies such as WP 6A which addresses broadcasting standards and WP 5A which deals with BWA standards.

Regarding the IMT standardisation influence on technology selection, the data analysis of the interviews revealed two views. On the one hand, there is a view that being part of the IMT family has a positive influence on the regulators' decision regarding technology selection to be from the IMT standards. This is due to several reasons. Firstly, IMT could be considered as an encouragement for countries to adopt internationally accepted standards. It is also argued that it is in the interest of a country to comply with IMT in order not to lose the benefits of economies of scales and roaming. In addition, IMT technologies are recommended by the ITU-R in its recommendations.

Besides, being IMT is necessary to define sharing conditions with neighbouring services and indicates that the used equipment will be consistent with frequency bands and will offer backward compatibility in terms of the previous generations of equipment. One additional point is that the developing countries, which lack technical resource to judge technologies, rely heavily on the ITU-R recommendations. In these countries, it is important for manufactures to get their technologies listed in the IMT to argue at the developing countries that it is one of the technologies that are used by the majority of the world.

On the other hand, there was a view that being one of the IMT technologies is not related to regulators' decision regarding technology selection for several reasons. Firstly, what matters regarding the technology is to be worldwide technology with low cost handsets more than being standardised by the ITU. For instance, one senior interviewee from the mobile industry in Africa mentioned that regulators in Africa did not know if CDMA-2000 is one of the IMT-2000 family or not but it was the vacant spectrum that attracted the vendors to deploy the technology in Africa. Having a technology out of the IMT family (e.g. IBurst) depends on whether the technology is capable of solving a problem in a particular country. One senior interviewee from CEPT argued that the influence from CEPT and European Commission (EC) is more important than the influence of IMT in Europe. All the different views regarding the influence of IMT on technology selection are displayed in Figure 2 (below).

¹WP 5D is responsible ITU-R WP for the overall radio system aspects of IMT systems, comprising the IMT-2000, IMT-Advanced and IMT for 2020 and beyond.

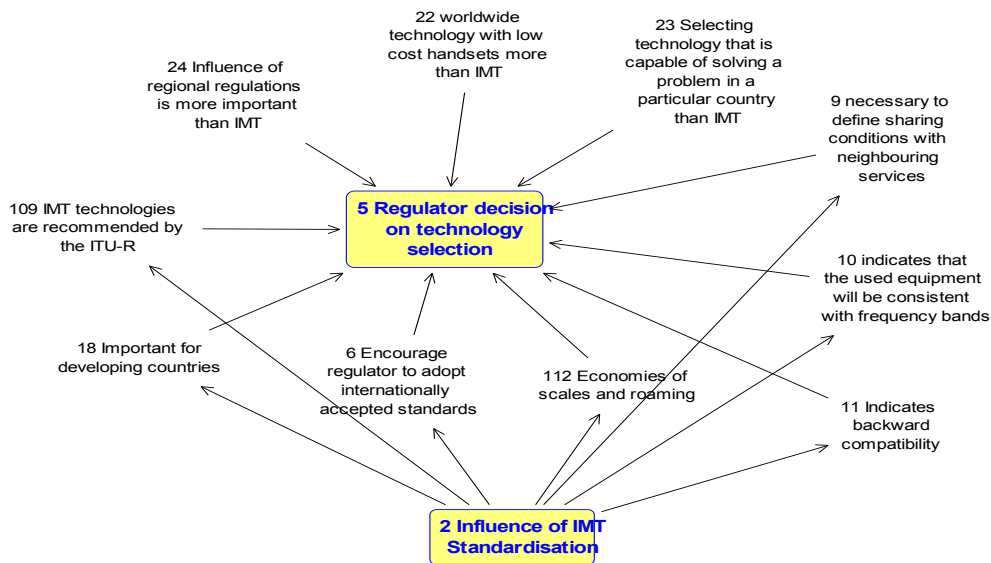


Figure (2): Influence of IMT Standardisation on Regulator's Decision on Technology Selection

Figure 2 reveals two different views on the importance of being one of the IMT technologies that regulators include in their deliberations. While one view is that such influence is significant for a variety of reasons (concepts 18, 6, 112, 10, 9, 11, 109). On the other hand, there was a view that being a IMT technology is a second priority to other factors that have a greater influence on the regulator's decisions on technology (concepts 24, 22, 23).

Regarding the influence of IMT standardisation process on national regulators regarding technology neutrality, the interviews revealed three views. The first view is that the IMT process has influenced positively regulators' approach towards neutrality for several reasons. Firstly, the standardisation process in ITU-R has helped the regulator to move forward to more technology neutral approach. In particular, IMT encourages regulators to have licenses that allow any IMT technology or any technology that complies with the emission mask of IMT. For instance, it has encouraged the European countries to be more neutral especially at the time when they were limited to ETSI technologies and companies such as Qualcomm wanted to bring CDMA 2000 with the 3G auctions in Europe.

Furthermore, it was argued that IMT encourages regulators to have licenses that allow any technology that complies with the emission mask of IMT. In addition, the IMT concept gives regulator the possibility to a greater extent to introduce more technology neutrality regulation because there is a family of technology, which can be used. Also, although there

are certain requirements and conditions for a technology to be part of the IMT family, this is not considered as a constraint. This is due that access of a technology into IMT standards is open provided those technical conditions can be met. Furthermore, all technologies applied for IMT-Advanced were approved and if there is another technology comes along, they could be included on the condition they meet the requirements of IMT. As expressed by one of the interviewees *“let's not speak of IMT technologies; it's wrong. IMT is like a system objective. Any technologies which met the minimum objectives are welcomed”*.

Moreover, while it is not mandatory to be IMT technology to be adopted, almost all technologies are part of the IMT family. Therefore, even if a regulator is technology neutral, most probably the adopted technology would be IMT. One other interviewee argued also that the intention of the ITU-R is not to make any IMT mandatory. As explained by him *“It is because the ITU does not want to impose too many things on its membership... ITU standards are actually a catalogue of possible solutions but none of them is imposed”*. In particular, countries are sovereign and there is nothing that mandates them to adopt IMT standards. Therefore, it is up to national regulators to reference or just acknowledge IMT.

Besides, the IMT process was an open and transparent, and involved independent assessment groups. Therefore, there was no a priori judgement against any specific technology. This was supported by another interviewee who argued that the IMT process is technology neutral itself because the process has defined what the specifications of quality and performance are. Accordingly, the different technologies, which can meet these objectives of performance, are called IMT. In addition, even within technology neutrality, technical conditions are designed with some assumptions on the technology, which uses frequency band, which could be IMT.

Regarding non-IMT technologies such as IBurst, it was pointed out that the ITU has not stopped the IBurst from operating because there was a different model for IBurst that is based on operating in particular guard bands. Instead, IBurst was not successful due to the advancement of LTE and lack of handsets rather than not being one of the IMT family.

On the other hand, there was a view that specifying technologies to be only IMT is restrictive and not neutral as it looks. As expressed in this quote *“you realize you are doing subsection of technology neutrality”*. Firstly, having a defined family of standards such as IMT discourages regulators from being neutral as it would be easier to limit the access to the spectrum to the IMT family of standards. This is one of the reasons why WiMAX fought to be one of the IMT standards. Secondly, it limits operators' ability to move to a more efficient

technology when it becomes available. Thirdly, it was perceived that in cases where countries issue license for IMT, at the end of the day this prescribes that operators will use LTE.

Moreover, one interviewee argued the IMT is used to keep out the competitive technologies off that list. One other view is that introducing new radio interface into the IMT family is quite difficult and requires a lot of time and money. Furthermore, although neutrality and IMT standards may be independent, the concept of IMT harmonisation is more or less against technology neutrality.

IMT process may restrict innovation in new technologies. In particular, companies supporting the 4G technologies want to postpone the discussion on 5G. As expressed in this quote *“From a bipolar world of ‘90 you move to unipolar world, and the unipolar world is IMT and because of that the innovation has taking a little back seat...governments in the world is focused on how do we make use of this technology, how do we make it more useful to us, rather than thinking what's next”*. In other words, while there was competition in the early days of personal mobile communication, between GSM and CDMA, today LTE is the dominant technology. This has resulted in moving the focus from the development of the next technological generation to the utilisation of the current generation instead.

The third view is that both issues of IMT standardisation and applying technology neutrality are independent and that the influence of IMT is more on the manufactures rather than the regulators. In particular, some countries adopt technology neutrality before the beginning of the IMT standardisation activities. Instead, it is the technology development that drives the neutrality issue due to the need to deploy other advanced technologies in the same spectrum band without getting a new license every time. In support of this, one interviewee stated that *“Technology neutrality is really something which is for the regulator. This is not something that the ITU cannot mandate or orient it in any way”*. All the different views regarding the influence of IMT on technology neutrality are displayed in Figure 3 below.

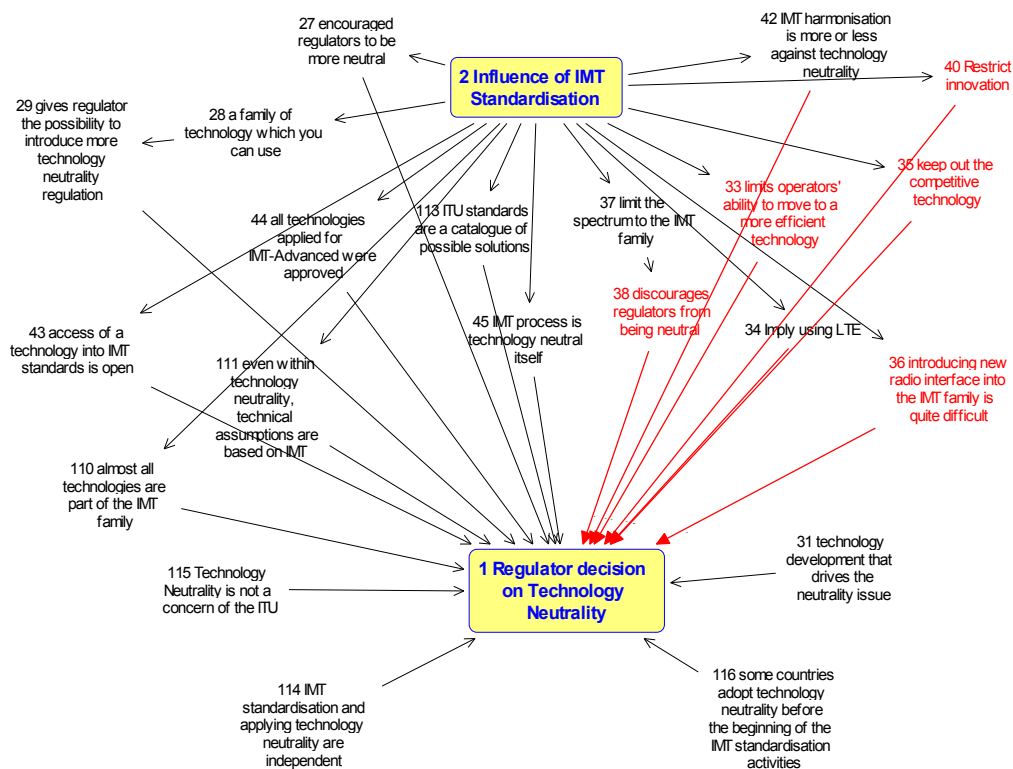


Figure 3: Influence of IMT Standardisation on Regulator's Decision on Technology Neutrality

Regarding the influence of IMT standardisation on technology neutrality, the map in Figure (3) shows the complexity of the issue. In particular, there are elements that encourage more neutrality approach in technology selection (concepts 28,29,27), and elements that support the argument that the IMT family of standards is considered to be in conformity with technology neutrality (concepts 43, 110, 44, 111, 113, 45).

The map also highlights the contrast view that the IMT standardisation is against the concept of technology neutrality and may discourage regulators from being neutral for several reasons (concepts 37, 38, 34, 42). The map shows that the IMT standardisation process may have negative influence on operators (concept 33) and technology developers (concepts 35, 40, 36). Moreover, there is an argument that IMT standardisation does not have influence on adoption of technology neutrality (concepts 31, 114, 115, 116).

These findings highlight that being part of the IMT family of standards provides support to the applicant technologies. However, there are other elements that may have

stronger influence on decisions regarding adopting a particular technology rather than being IMT technology. Moreover, IMT standardisation has positive (supportive), negative (opposing), and neutral elements in terms of the influence on regulators regarding technology neutrality according to the perception on technology neutrality and on the IMT standardisation process per se.

6. Influence of IMT Standardisation on Perspectives regarding Mobile Technology Generations Definition

This section addresses the second of the four research questions outlined in section 2, which is the influence of the IMT standardisation process on the perception of mobile technology generation definition. More specifically, it is important to examine whether the ITU-R definitions of IMT-2000 and IMT-advanced technologies have an influence on the perception and differentiation between 3G and 4G services.

In general, there are two distinct views on the influence of IMT on mobile technology generation definitions (3G, 4G). The first view is that there is no influence for the following reasons. Firstly, it was explained that 3G and 4G are marketing terms that have nothing to do with the ITU. In particular, the ITU has been reluctant to use these marketing terms (e.g. 3G, 4G) because the marketing way of the state of technology is an evolutionary change (e.g. 3.75, 3.9) rather than revolutionary change (IMT-2000, IMT-Advanced). Moreover, there was a decision in the WP 5D not to use the terms of 3G and 4G. As expressed in this quote *“The ITU would not be called caught in a situation of giving a false expression impression”*.

Moreover, it was expressed that the IMT umbrella provides a high level of definition and that the ITU-R sets vision without much detail. One interviewee who is involved in the activities of the WP 5D argued that the influence of the IMT was much less in the case of 4G than the 3G as certain regulators were not concerned with the term IMT-Advanced. Moreover, the industry parties did not care much about what the ITU-R was doing in the case of IMT-Advanced. This interviewee’s remark supports this: *“There were those in the marketplace who felt that their position in the marketplaces as operators or others was enhanced by waving a flag saying, We are 4G, therefore we do not care to have 4G defined, because if it is defined, it's probably not going to be what we are doing”*.

On the other hand, the second view is that the influence exists between IMT standardisation and technology generation definitions. In particular, it was argued that the commercial and IMT definitions go hand in hand and that the ITU-R definitions were

strongly influenced by the industry representatives at the WP5D meetings. In particular, it was argued that there was influence in the case of 3G because it was an emerging green field market as the ITU-R recommendation M.1457 stated clearly that these are the 3G technologies, which made a clear distinction between 2G and 3G.

One interesting remark was mentioned during the interviews regarding the influence of technology developers on the IMT definitions is that originally CDMA 1X was not a 3G technology according to the ITU-R definitions, which was a problem for Qualcomm. Accordingly, Qualcomm asked to slightly change the definitions at the ITU-R from only 2 Mbps to accommodate 144 Kbps for mobile use, which was exactly what CDMA 1X provided.

One issue that was raised during the interviews is the influence of IMT standardisation on the definition of 4G. More specifically, the data has revealed the view that LTE and its evolution form are branded as IMT-2000 according to the ITU-R recommendation ITU-R M.1457, and LTE-Advanced is categorised as IMT-Advanced according to the recommendation ITU-R M.2012. Therefore, only LTE-Advanced is considered as 4G.

The other view emerging from the data is that for regulators, LTE is 4G even if the ITU-R does not categorise it as IMT-Advanced. As clarified by one of the interviewees “*If 4G is IMT-Advanced, nobody has it*”. One interviewee who is involved in the WP 5D activities argued that there is no real strict definition for 4G. He highlighted an example in the US where T-Mobile came out and stated that “*We do not have any LTE, we do not have any IMT-Advanced, we do not have any of this and that. But what we've got is 4G, because it's fast*”. Moreover, the influence on commercial definition varies from country to another. For instance, in Japan, LTE is understood to be 3G.

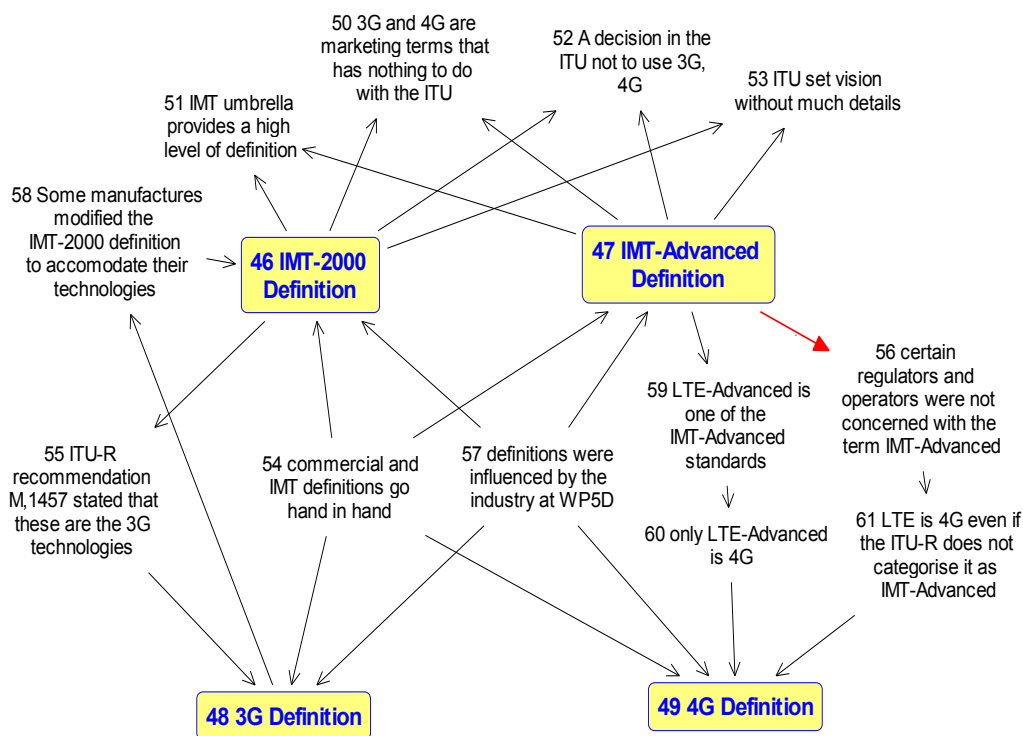


Figure 4: Influence of IMT Standardisation on Perspectives regarding Mobile Technology Generations Definition

The causal map shown in Figure 4 reveals several observations on the interaction between the IMT standards on the one hand and the 3G and 4G definitions on the other hand. Firstly, several actions were taken in the ITU-R to diminish any influence from the IMT standards on the technology generations terms used in the market (concepts 51, 50, 52, 53). On the other hand, there is a view that both IMT and commercial definitions are developed in parallel (concept 54) and that both definitions are influenced by the industry (concept 57). Regarding the influence from the industry on the IMT definitions, there is a view that there was an influence specifically from the market on the IMT-2000 (concept 58). Similarly, there was an influence from the IMT-2000 definitions on categorising what should be labelled as 3G.

Regarding the 4G, there are two views. The first is that only LTE-Advanced is considered to be 4G because only LTE-Advanced is included in the IMT-Advanced standards and not LTE. The second view is that this is not the case as LTE is still considered by many as 4G technology although LTE is not one of the IMT-Advanced technologies. These

observations imply that while one view is that there is mutual influence between the IMT definitions and definitions of 3G and 4G, the other view is that there is no influence because the ITU-R has taken several actions not to influence the market terms.

7. Influence of IMT Standardisation on Discrimination between Technology Generations

This section addresses the third of the four research questions outlined in Section 2, namely, the influence of the IMT standardisation on the discrimination between mobile technology generations. In particular, the analysis of the interviews revealed two views. The first is that there is no influence on the discrimination between generations. In particular, the issue of having IMT-2000 and IMT-Advanced under one label named IMT has provided more flexibility in the spectrum use. Accordingly, most regulators have started to use IMT as a single name so that operators can move from technologies such as WCDMA to LTE directly. This was also confirmed by one other interviewee who argued that the ITU-R does not mention IMT-2000 or IMT-Advanced anymore. Instead, the use of the term IMT shows that neutrality of system in spectrum bands is already under consideration by ITU-R. However, this may not be the case for some regulators because they have the licenses with specific conditions.

One interviewee clarified the origin of the decision of having IMT-2000 and IMT-Advanced under one label. In particular, it was mentioned that the ITU-R actually banned the 3G and 4G terms and started removing it from all the ITU-R documents. This is due that the original intention was that IMT-2000 was 3G and IMT advanced was 4G. However, there were technology upgrades within IMT-2000 and those upgrades have been called 4G, which was confusing. The reason for having one label, IMT, was to ensure that the footnotes in the RR identified spectrum for IMT could be used for all of the technologies instead of having spectrum identified separately for IMT-2000 and IMT-Advanced. Another reason for having the IMT label was that IMT-2000 was expected to be deployed around the year 2000 and to be linked to the 2000 MHz band, which was not the case eventually. More specifically, IMT-2000 was not limited to the 2000 MHz band and was not necessarily deployed in the year 2000. Therefore, it was decided to just call it IMT.

One point that was raised is that although LTE is included in the ITU-R recommendation M.1457 and LTE-Advanced in ITU-R recommendation M.2012, LTE release 10 will also be included in M.1457. As expressed by one of the interviewees “*They’re going to keep updating on it, so they were going to have it in both places*”. Therefore, there

would be an overlap between the two recommendations so that there would be no discrimination between IMT-2000 and IMT-Advanced. In addition, one senior interviewee clarified that one of the requirements for IMT-Advanced was to be backwardly compatible with the IMT-2000 to ensure that there is an evolution between the two of them.

A senior interviewee from the mobile industry argued that the differentiation is due to historical reasons as most of the 3G licenses were awarded by beauty contest. As stated by him *“all the history of what we done in the past probably drive the resistance to making it completely technology neutral”*. More specifically, the relatively higher license fees paid in some of the 3G licenses made it difficult for the regulators to allow operators who have spectrum used for 2G technologies to use it for 3G. Moreover, it was argued that the license matters are really a national consideration that the ITU-R does not get involved in.

It was also mentioned that regulators differentiate between generators not only for getting higher license fees but also in terms of prestige. As expressed by one of the interviewees *“I had noticed in countries in Latin America is that is a matter of prestige, when the government says ah we have the latest technology this is 4G and that’s spectrum they make a big fast of update”*. In addition, regulators usually refer to the common practise rather than the ITU-R.

On the other hand, there was a view that having IMT-2000 and IMT-Advanced labels could be used as an excuse for regulators to differentiate between technologies. As expressed by one of the interviewees from WP 5D *“It has an influence. But everything has an influence. It could be used that way”*. It was also mentioned that this is not the intention of the ITU-R. One senior interviewee from the mobile industry highlighted the issue of EDGE being considered as 3G due that it was included in the IMT-2000 family although EDGE was obviously a 2G standard. He further raised the point that the LTE technology may face similar situation because it is mentioned in IMT-2000 and IMT-Advanced recommendations.

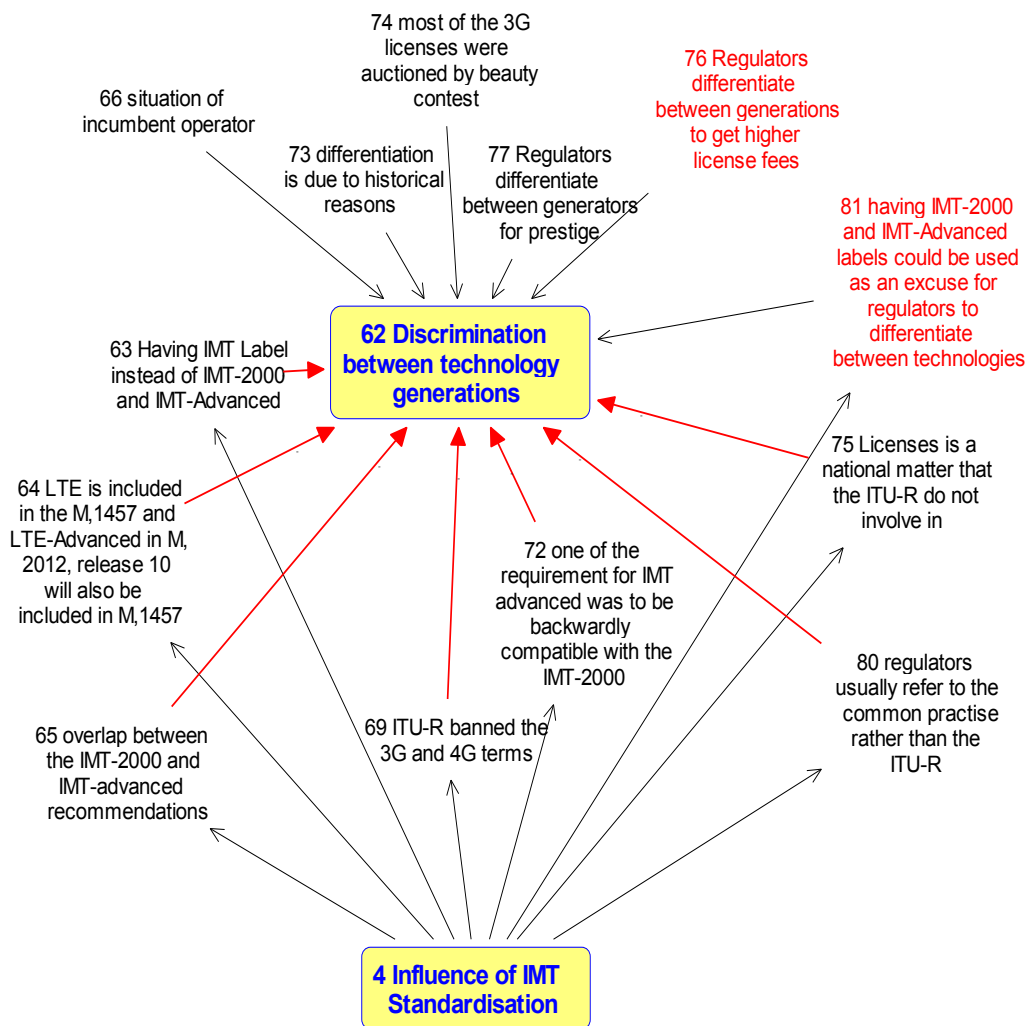


Figure 5: Influence of IMT Standardisation on Discrimination between Mobile Technology Generations

The causal map in Figure 5 shows that there are several reasons why regulators differentiate between technology generations due to issues related to the telecommunication market circumstances on the national level (concepts 66, 73, 74, 77). In addition, regulators may discriminate between the different technology generations in order to acquire higher license fees (concept 76). Regarding the influence of the IMT standardisation process of such discrimination, the map shows that the ITU-R by different actions has reduce the variation between IMT-2000 and IMT-Advanced (concepts 64, 65,72) and by not being involved in the discussion related to the differentiation between 3G and 4G (concept 69). The ITU-R does not involve in national matters (concept 75) and national regulators usually refer to the

common practise rather than the ITU-R (concept 80). However, there was view that national regulators could use the IMT-2000 and IMT-Advanced labels to justify such discrimination (concept 81). Therefore, these findings show that the IMT standardisation has mostly no influence on the discrimination between technology generations on the national level.

8. Influence of IMT Spectrum Identification on Technology Selection and Technology Neutrality

One area that needs further focus is the IMT spectrum identification in the RR. This is due that it is not usual in the RR to have spectrum identified specifically for a particular technology. Instead, spectrum is allocated to radiocommunication services (e.g., fixed, mobile). Several interviewees commented on the influence of spectrum identification on regulator's decision on technology selection. Firstly, it was perceived that the ITU is one of the most authorised entities in telecommunication world, and therefore, many vendors and operators like to have authorisation of the ITU for the used frequency bands.

Therefore, the identification sends strong signals to the manufacturers of the equipment that these are the bands that they should focus on and concentrate on in developing mobile technology in order to achieve harmonisation, roaming, and economies of scales. This is due to the fact that there are technological limitations so that it is only possible to have a handset that supports specific bands. The alternative would be to consider all the spectrum bands allocated to mobile service.

This was also supported by a senior interviewee from the mobile industry who stated that *“we do not want to go down the road and develop something if it is not going to see the light at the end of the day”*. The identification sends also signals to the regulators to make sure that they had these identified spectrum band that could be used for IMT at an appropriate time when they decided to introduce it into their countries. In addition, designation or identification was argued by several interviewees to make spectrum more valuable. As expressed in this quote *“physics did not change, but the fact that you now designated IMT suddenly you raking in millions”*.

One other interviewee argued that such identification could raise the value of spectrum and increase the license fees that operators are willing to pay. This was confirmed by a senior interviewee from CEPT, who explained that IMT identifications through WRCs have been always followed by spectrum awarding activities. Moreover, IMT spectrum identification is important for regulators, which are not as advanced as large regulators (e.g.

FCC) in terms of making their own decision. For these regulators, it is difficult to conduct studies to decide on which bands would be used for IMT technologies. Instead, they rely on the ITU to take such decision.

Another advantage that was mentioned is that when you auction spectrum bands identified for IMT technologies, there is a guarantee that you will have operating devices in these bands. Besides, a senior interviewee explained that the identification is an indication that most of the countries using this service in the particular band will follow the IMT standards. In addition, one interesting point that was raised by one of the interviewees is that having a particular spectrum band identified for IMT gives support to the regulator to re-farm the spectrum from its existing use.

An example for that is the 700 MHz band IMT identification where several regulators were considering deploying mobile service in the 700 MHz. In his own words:

They did not want to even mention it because they knew that the broadcasters in their country, TV broadcasters, will be very upset, will make a lot of fuss and it will be very difficult. But once the ITU has said this band is going to be used for mobile, it made it much easier for regulators to say, well this is not my idea but look the rest of the world think this band should be 700 MHz.

The interviewees mentioned several case studies that show how the influence of IMT spectrum identification is different from country to another. For instance, one senior interviewee from Region 2 highlighted the case of WRC-07 where the issue of IMT identification in the C-band was discussed. At the time of the conference, the band was already allocated to mobile service but not identified to IMT. The European countries wanted to have the band identified to IMT and the opposing countries wanted to put restriction on IMT in order to protect the other services operating in the band. In particular, countries of region 2 did not want to have restriction on the use of the band as it is already allocated to mobile service. Therefore, they decided not to have the band identified for IMT while still using it for IMT due to the existence of mobile allocation.

In addition, one other interviewee from the mobile industry explained that companies usually adopt IMT technologies in bands identified for IMT. However, there is one exceptional case in Japan where the 2.5 GHz was identified for mobile broadband in general and not only IMT. This was motivated by the request of one company to deploy WiMAX at the time where WiMAX was not yet part of the IMT family. When it was asked whether it is mandatory to deploy only IMT systems in bands identified for IMT, it was clarified that this is not strictly specified but there is no need for operators to adopt a quite different interface for that IMT frequency band.

It is worth mentioning that several interviewees highlight some deficiencies associated with IMT spectrum identification although they may not be related to regulators' decision on technology selection. Firstly, it is difficult and takes a long time to get an agreement on IMT identification through WRCs. The case of IMT identification has encouraged other technology developers to seek identification (e.g. High Altitude Platform Stations (HAPS)). Another difficulty is that while the first IMT identified bands were fully harmonised, it has become more difficult to find harmonised bands throughout the world considering the increasing number of identified bands. In particular, it has become not economical approach to have radio equipment that can support this large number of frequency bands. Identification is also considered as a barrier for emerging technologies, and identification gives less incentive for manufactures to be innovative and produce equipment that works across much more wider range of frequencies.

Moreover, IMT identification is considered as disadvantageous to other radiocommunication services, which do not want the IMT to get their spectrum. As explained by one of the interviewees *“A lot of people think that commercial mobile industry is very arrogant and does not need as much spectrum as they keep asking for, and so there is a backlash against the identification to IMT”*. In particular, many entities participate in the ITU-R discussion to restrict IMT access to spectrum (e.g. satellite, broadcasting). Additionally, one interviewee raised an interesting point related to the competition of IMT with other radiocommunication service, which is that IMT identification is not considered by many as identification for particular technologies. Instead, it is like service allocation where you can use IMT technologies.

In his own words *“It is like saying we think that spectrum is identified for the commercial mobile service, or a commercial mobile application, and you can use IMT technologies”*. This was confirmed by one senior who is involved in the WP 5D activities who argued that IMT is not strictly identification for a technology because IMT is not only technology but also services vision. Another noticeable observation by one of the interviewees is that the IMT identification could be perceived as an allocation to a combined service of fixed, mobile, and broadcasting.

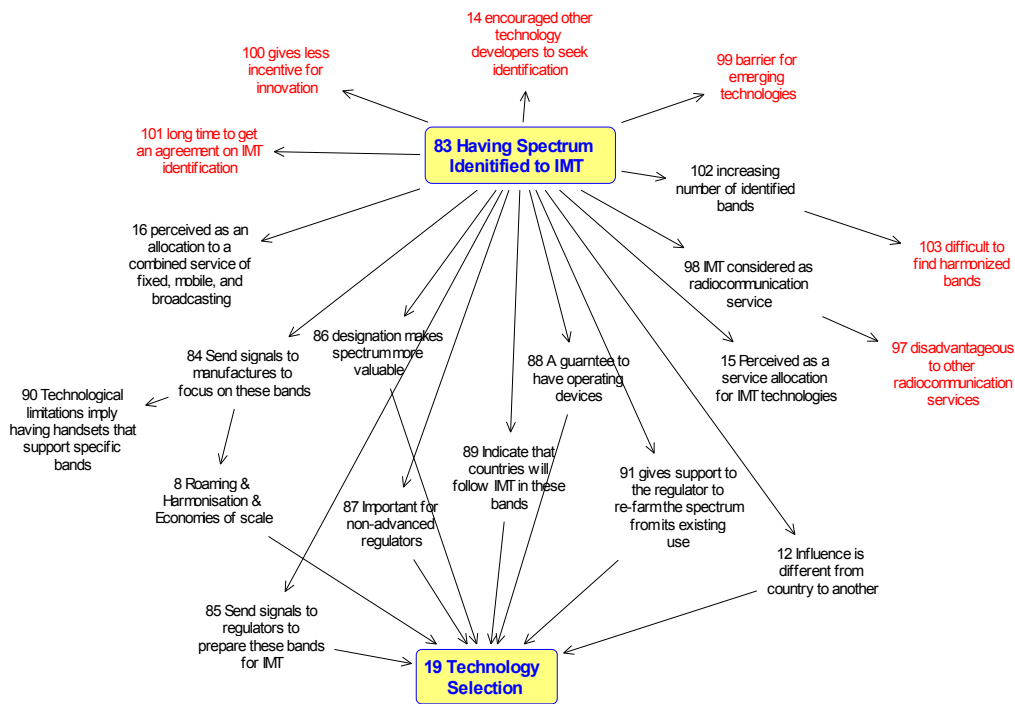


Figure 6: Influence of IMT Spectrum Identification on Regulator Decision on Technology Selection

Figure 6 shows how IMT spectrum identification has different but positive influences on the decisions of regulators regarding the selection of technologies from the IMT family (concepts 84, 8, 90, 85, 86, 87, 88, 89, 91). However, it was noted that such an impact is dependent on the country (concept 12).

In addition, several more general observations emerged from the interviews. Firstly, IMT spectrum identification may have a negative influence on new technologies and on innovation (concept 99, 100). Secondly, within ITU-R, reaching agreement on identification is difficult (concept 101) and other technologies related to other services rather than mobile have started to seek identification and not only service allocation (concept 14). The increasing amount of spectrum for IMT has made harmonisation more difficult (concept 103). One observation was that IMT identification is perceived by some as an allocation to a radiocommunication service rather than just identification of a technology (concept 15).

Moreover, such allocation is envisioned as multiple allocations to fixed, mobile and broadcasting rather than just an allocation to a mobile service (concept 16). In other words, it could be argued that IMT identification enables more flexibility in service allocation as it accommodates elements from three main services (fixed, mobile and broadcasting).

Furthermore, the issue that IMT spectrum identification is disadvantageous to other radiocommunication services (concept 97) could be perceived as supporting the argument that IMT identification implies deploying IMT even if the band has other service allocations.

Regarding the influence of IMT spectrum identification on regulators regarding technology neutrality, there were two views. The first view is that identification does not negatively influence technology neutrality. In particular, IMT identification does not preclude other use for the spectrum. There is no restriction on re-farming to other technologies because in the same part of the spectrum, the technology will be similar whether the band is identified for IMT or not. Moreover, there was an influence of IMT identification on removing the link between technology and spectrum that used to be. In particular, there used to be a link where GSM operate in the 900 MHz and 3G was linked to 2 GHz band. Regarding the case of having mobile technology in the L-Band as SDL, while the band is not yet identified to IMT and only allocated to mobile services, it is not necessary to wait for WRC-15 to confirm this identification. Instead, work has already started in standardisation organisations such as 3GPP. This may show how mobile development is not limited to IMT spectrum identified bands.

On the other hand, there were several negative comments on the influence of IMT spectrum identification. Firstly, one difficulty for IMT identification is that it is considered as disadvantageous for other mobile use in the identified bands rather than IMT (e.g. TETRA - IBurst). More specifically, it becomes only possible for non-IMT technologies to be deployed in non-IMT identified bands. An evidence of that is that non-IMT technologies were proposed in bands not identified for IMT. For instance, IBurst technology, which was proposed in the duplex gap of the 1800 MHz where there is no IMT equipment. However, IBurst was not able to outperform IMT technologies. Therefore, it was argued that any proprietary technology would not be able to compete in the market with IMT technologies regardless of the regulator decisions. The only exception would be in huge markets driven by government owned manufactures.

Furthermore, linking spectrum to IMT may restrict re-farming in general. More specifically, it could be considered as a good excuse for regulators not to apply technology neutrality and to limit the use of a particular band to be for IMT exclusively. In addition, it was pointed out also that having the band identified for IMT would mean an implicit use for LTE in the future. This was confirmed by a senior interviewee from Africa who argued that although some regulators may be neutral; having the IMT technologies with all its advantages motivate them to pick IMT technologies. Moreover, one senior interviewee from the mobile

industry argued that while there is no relationship between applying technology neutral and having IMT spectrum identification, having such identification encourages regulator to identify the band for IMT. In other words, the spectrum identification process focuses the attention on IMT solutions as opposed to alternative technologies even if such identification does not preclude other uses.

Additionally, one senior interviewee from the mobile industry argued that IMT identification would imply using the band for IMT. For instance, regarding the 700 MHz allocation, there was a suggestion to allocate the band to mobile service without IMT identification so it would not give signals that the spectrum is moving from the broadcasters to mobile operators. This highlights the major influence of IMT identification and the difference from normal mobile service allocation as it largely implies using IMT.

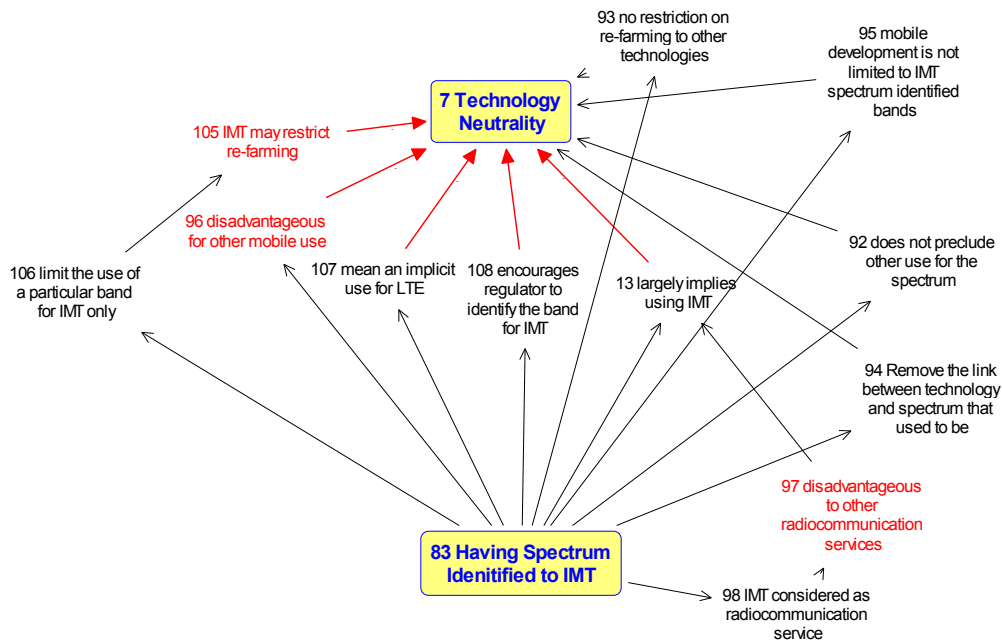


Figure 7: Influence of IMT Spectrum Identification on Regulator Decision on Technology Neutrality

Regarding the influence on technology neutrality, there were several perceived positive and negative elements that have an influence on the concept of technology neutrality as clarified in Figure 7. On the one hand, having spectrum identified to IMT may largely imply using the spectrum for IMT, which may discourage regulators to apply technology neutrality and to limit the band use to IMT only instead (concepts 106, 105, 96, 107, 108, 13). On the other hand, such identification does not preclude other mobile use (concepts 92, 93)

and mobile development has been progressed in bands other than those identified for IMT (concept 95). Moreover, the IMT spectrum identification was argued to contribute positively to the introduction of technology neutrality (concept 94).

This leads to a conclusion that IMT spectrum identification has a positive impact on regulator decision towards selecting technologies from the IMT family. However, the extent of such influence is dependent on the country. Moreover, IMT spectrum identification has elements of flexibility and restriction on the concept of technology neutrality.

9. Conclusions

Technology selection is one of the main elements of any spectrum management approach where selection of technologies could be neutral, restricted to standardised technologies, or selective of specific technologies. Firstly, standardisation refers to the level of specification of allocated services such as transmitter power, channelization, and interoperability. On the other hand, technology neutrality is defined as the minimum applied constraints while ensuring that interference is appropriately addressed. Technology neutrality is one element of the spectrum market approach, which is proposed to overcome the deficiencies of the command and control approach to spectrum management.

The ITU-R work on standardisation of 3G technologies started by inviting applicants for IMT-2000 radio transmission technologies in 1997. In addition, five terrestrial radio interfaces were approved to be part of the IMT-2000 standards. Later on, the WiMAX was included after oppositions from several countries and industry bodies within the ITU-R. Regarding the 4G standards, two IMT-Advanced technologies namely, LTE-Advanced and WirelessMAN-Advanced were approved as IMT-Advanced standards. Moreover, the IMT standardisation process has been always associated with identifying spectrum for the use of IMT standards by the ITU-R. Different spectrum bands in higher and lower frequencies were identified for the use of IMT standards by the last WRCs.

With regard to the paper's first question, on the influence of IMT standardisation on technology selection and technology neutrality nationally, the analysis of the interviewees' data with regard to the interaction between the international spectrum management regime and national spectrum management policies in terms of technology neutrality has shown the followings. Firstly, it could be concluded that being part of the IMT family of standards provides support to the applicant technologies. However, there is another view that being

IMT technology is a second priority to other factors that has a greater influence on regulator decision on technology.

It was found also that IMT standardisation has positive (accommodating), negative (restrictive), and neutral elements in terms of the influence on regulator's decision regarding technology neutrality according to the perception on technology neutrality and on the IMT standardisation process per se. The first view is that there are elements of IMT standardisation that encourage more neutrality approach in technology selection, and the IMT family of standards is considered to be in conformity with technology neutrality. The second view is that the IMT standardisation may discourage regulators from being neutral, and may have negative influence on operators and technology developers, and the third view is that IMT standardisation does not have influence on adoption of technology neutrality.

With respect to the paper's second question regarding the influence of IMT standardisation on perspectives regarding mobile technology generations definition, the analysis has shown also that while one view is that there is mutual influence between the IMT definitions and definitions of 3G and 4G because both definitions are developed in parallel and both definitions are influenced by the industry, the other view is that there is no influence because the ITU-R has taken several actions to diminish any influence from the IMT standards on the technology generations definitions used in the market.

Regarding the paper's third question on the influence of IMT standardisation on discrimination between mobile technology generations, the interviewees expressed that IMT standardisation has mostly no influence on the discrimination between technology generations on the national level. This is due that regulators differentiate between technology generations due to reasons related to the telecommunication market circumstances on the national level rather than reasons related to IMT. Moreover, the ITU-R has undertaken several actions to reduce the variation between IMT-2000 and IMT-Advanced and not to be involved in the discussion related to the differentiation between 3G and 4G. However, regulators could use the IMT-2000 and IMT-Advanced labels to justify discrimination between technologies on the national level.

With regard to the paper's fourth and final question exploring the influence of IMT spectrum identification on technology selection and technology neutrality, it was evident that such identification has a positive impact on regulator decision towards selecting technologies from the IMT family. However, the extent of such influence is dependent on the country. In particular, identification makes spectrum more valuable, and having a particular spectrum

band identified for IMT gives support to the regulator to re-farm the spectrum from its existing use. Additionally, it was revealed that IMT spectrum identification has elements of flexibility and restriction on the concept of technology neutrality. Firstly, restrictive elements include having spectrum identified to IMT may largely imply using the spectrum for IMT which may discourage regulators to apply technology neutrality and to limit the band use to IMT only instead. Secondly, flexible elements include that such identification does not preclude other mobile use and that mobile development has been progressed in bands other than those identified for IMT.

In general, the analysis has demonstrated that the international spectrum management regime does not prevent the adoption of technology neutrality. However, there are different elements of support and opposition that have an influence on the regulator's stance towards technology neutrality. These elements are dependent on a country's geographical position, its perceptions on technological neutrality, the size of country's market, its level of technological advancement, interpretation of international regulations and the status of the national telecommunication market.

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