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5G AS DISRUPTIVE INNOVATION: STANDARD AND REGULATORY CHALLENGES AT A COUNTRY LEVEL

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ABSTRACT

Understanding 5G from a perspective of innovation is to explore both technical research and development (R&D) and non-technical issues. While 4G has been considered as an incremental innovation from its predecessors (3G and 2G), design features and key technologies have indicated 5G as a disruptive innovation. Consequently, 5G will create new market values, in which new services and applications will emerge in unexpected ways. Hence, it is predicted that policy makers will face significant challenges concerning 5G implementation in their respective countries. This paper aims to investigate the challenges to standards and regulations at a country level. The discussion begins with the challenges because of the emergence of non-human markets as well as the complexity of multi-device technological platforms. Due to anticipated massive cloud-based applications, security issues of cloud-based applications will be a subsequent challenge for national policy makers. Finally, as 5G may require various supporting technologies, the challenge for the policy maker is also to trigger national development of local standards.

Keywords: Disruptive innovation; Mobile technology; Policy maker; Regulation; Standard

1. INTRODUCTION

The development of 5G mobile technology is a global R&D initiative, involving worldwide research, academia, and multinational industries. Under the ITU standardization body, 5G has been labeled as IMT-2020. Yet, despite the fact that standards are not yet maturely defined, all have shown a consensus on 5G visions. It is commonly noted that 5G will be built from several key technologies (Andrews et al., 2014; Felita & Suryanegara, 2013; Boccardi et al., 2014; IMT-2020 Promotion Group, 2014), emphasizing the very high speed data rate on a large bandwidth.

It is believed that 5G technical realization may come to the market by the next decade. By that time, most countries will have already rolled out 4G and 3G. Therefore, once 5G is implemented, a country regulatory body will govern the technological change from 4G to 5G. However, determinants of technical change cannot be separated from institutional change (Mansell, 1998). Therefore, it is important for a policy maker to anticipate and to prepare for the coming of the new technology. Early anticipation is needed, so that the arrival of the new technology will be swiftly adopted by the market. In the field of mobile technology, the role of policy makers may refer to the national regulator (government). Thus, some issues to be addressed are: What is the non-technical impact? How will 5G affect the country's industrial

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ecosystem? How will the regulatory regime build its response?

An approach based on innovation studies is proposed. The underlying concept is to regard 5G as disruptive innovation. This point of view may foster our understanding, since the concept of 'disruptive' provides relevant consequences and ideas. Why innovation studies? The perspective of innovation finally leads to economic performance, in which the national policy makers (government) establish industrial policy over a technological sector. In general, the industrial policy has "the first best" objective to compensate for various perceived market failures and "second best" attempts to exploit market imperfections to benefit the domestic economy (McFetridge, 1999).

This paper comprises six sections. The second section discusses commonly accepted 5G visions, while the third discusses the framework from a disruptive innovation perspective. A subsequent perspective of 5G as disruptive innovation is presented in the fourth section. The fifth section presents the discussion of standard and regulatory challenges, while the conclusion is presented in the sixth section.

2. 5G VISIONS

The consensus of academia and industry devise the 5G visions as centered on the increased performance of data rate by 1000× from 4G to 5G, while roundtrip latency is designed to perform at about 1ms (Andrews et al., 2014; IMT-2020 Promotion Group, 2014). 5G vision is not only driven by an explosive increase of the data rate but also by the number of interconnected devices (IMT-2020 Promotion Group, 2014). It was forecast that the amount of wireless IP data could exceed 500 exabytes by 2020 (Andrews et al., 2014), while many new applications would come to the market exhibiting extraordinary data flow. Apart from personal communications, we are hardly able to guess what kind of applications will present in future decades.

China's IMT-2020 Promotion Group has described the overall 5G visions in its 2014 white paper (IMT-2020 Promotion Group, 2014). Under such visions, 5G will touch many aspects of life in the future, characterized by three scenarios, i.e. ultra-high traffic volume density, ultra-high connection density, and ultra-high mobility (IMT-2020 Promotion Group, 2014). Some typical services, such as augmented reality, virtual reality, ultra-high-definition videos, cloud storage, Internet of Vehicle (IoV), smart home, and over-the-top (OTT) services, will take place in these scenarios.

Many researchers have worked to formulate key technologies to enable the realization of 5G visions. Table 1 lists a resume of the big three key technologies of 5G, which is discussed in (Andrews et al., 2014).

3. THE INNOVATION STUDIES APPROACH TO 5G

3.1. The Perspective of Innovation

The creation of innovation is always associated with the R&D activities of firms, countries, or sectoral industries. The basic concept is to always link output of such R&D with its commercial effect on the economy. As a result, R&D has a strong connection with industrial and national economic performance. The development of mobile technology is a R&D intensive sector. Hence, the innovation approach is essential when discussing such a topic.

It was also argued that new emerging technologies (such as mobile and Internet) have taken essential roles in the new telecommunications era, performing co-evolution with other factors and supporting the engine of innovation (Fransman, 2002). One of the key problems in

managing innovation is to make sense of a complex, uncertain, and highly risky set of phenomena (Tidd et al., 2005).

Table 1 The big three key technologies of 5G (Andrews et al., 2014)

Performance Target	*Key Technologies*	Issues
Extreme densifications to improve the area spectral efficiency	Extreme densification and offloading	- Base-station densification gain - Multi RAT association - Mobility support - Costs
Increased bandwidth	mmWave spectrum allocation of 30 – 300 GHz	-Propagation issues -Leveraging the legacy 4G Network
Increased spectral efficiency	Massive MIMO	- Pilot contamination and overhead reduction - Architectural challenges - Elevation beam-forming - Channel models - Coexistence with small cells - Coexistence with mmWave

In the sense of innovation study, we can refine innovation into incremental innovation and radical innovation. Under the concept of innovation study, the series of mobile technology from 2G to 3G and from 3G to 4G, can be regarded as a sequence of incremental innovation, since each emerges gradually with continuous improvement from the preceding technology. Meanwhile, radical innovation may refer to sudden emergence, and has no historical connection with any other product or services; the first version of WiMAX technology is an example.

3.2. Disruptive Innovation

Disruptive innovation is sometimes referred to as radical innovation. However, to make a clear distinction, we may say that the classification of "radical innovation" puts more emphasis on its historical emergence; while the classification of "disruptive innovation" is more about its impact and consequences on the economy. The work of Bower and Christensen (Bower & Christensen, 1995) has signified the role of disruptive innovations in creating new market value. Such disruptive technologies and innovations often create new market value in unexpected ways, both independently and through combination with existing standards and protocols (Bower & Christensen, 1995; Rao et al., 2006). When talking about their applications, the typical technologies are often cheaper and inferior in performance, yet they involve features that may provide competitive advantage in the future (Rao et al., 2006). On the other hand, most empirical studies have also shown that disruptive innovation need not necessarily be inferior in quality. For example, the storage-media technology of flash disc was superior to floppy disc.

Since the introduction of its terminology, disruptive innovation offers a very different package of attributes from those that mainstream customers historically value (Bower & Christensen, 1995). As a rule, at first, mainstream customers are unwilling to use a disruptive product in applications they know and understand (Bower & Christensen, 1995). Consequently in most cases, disruptive innovations often relate to "the fall of mainstream technology".

4. 5G AS DISRUPTIVE INNOVATION

Significant works in 5G research (Andrews et al., 2014; Boccardi et al., 2014) have described some technical aspects that could lead to disruptive changes in the implementation of 5G networks. Literature (Boccardi et al., 2014) focused on five technical aspects including device-

centric architecture, mmWave spectrum, massive MIMO, Smarter Device, and M2M communications. An important aspect of renewable energy, related to 5G small cell deployment, is also mentioned (Andrews et al., 2014).

From the domain of pure technical perspective, such technologies are qualified to be "disruptive", since they offer very different attributes from mainstream cellular generations (3G and 4G). For example, despite MIMO has been able to increase the capacity in many wireless platform (Arifin & Ohtsuki, 2013), 5G will require a new technique, so called massive MIMO. Another clear example is concerned with the mmWave spectrum. The technologies of 3G and 4G utilize the IMT-band which is mostly below 6 GHz. A disruptive change is there, indicated by the consideration of mmWave (30–300 GHz) spectrum allocations.

From a non-technical perspective, the 5G system could be disruptive when it offers new market value for mobile cellular users. The 5G vision has foreseen that the 5G market would no longer be just human, but all "things". 5G has come along with the rise of IoT (Internet of Things), as well as M2M (Machine to Machine). However, up to now, we can hardly answer the question of whether 4G will be killed by 5G. Will it become like VoIP devastating "voice call", or like a flash disk diminishing the floppy disk?

A daunting condition for industry is if 5G does not entirely support backward compatibility with preceding technological generations. Up to now, research works are saying that the evolution of LTE may not be sufficient to meet the anticipated 5G requirements (Andrews et al., 2014). Designed with disruptive technologies, 5G will come with a new smarter device as well as a new infrastructure. Consequently operators should make a new investment, and the costs could be huge, as these technologies are just evolving. The bigger picture can be drawn centering on the survival of the existing operators.

One of the crucial impacts of disruptive innovation, is that the new technology could diminish the old one. Further, the existing system could collapse due to the emergence of a new system. Therefore, a country's regulator has also a responsibility to ensure fairness and stability of industry. A collapse of operators would disrupt a national economy. In 2014, the mobile industry generated 3.8% of global GDP, a contribution that amounts to over US$3 trillion of economic value across 236 countries (GSM Association, 2015).

Thus, the next question to policy makers is how to ensure each 5G operator would have a safe revenue model. Policy makers should avoid a condition where only one big operator survives the new technology. In 2014, GSMA reported that revenue growth was forecast to slow further over the coming years, with a combined annual growth rate (CAGR) of 3.1% per annum through to 2020, down from just over 4% in the period 2008-2014, reflecting the ongoing impact of factors in this particular market maturity and tight competition (GSM Association, 2015).

5G cannot be a monopoly of new operators or strong operators only. A more clear explanation can be given by taking into account (Noble, 1986) the extension of power and control due to a new technology. If any operator establishes a monopoly, it will keep tight control over the market and close the doors of creativity. Demand would be restricted as the operators are driving the direction of the market. Such a situation could bring a negative effect on a firm's competitiveness and innovativeness.

Why would market fairness and competitiveness become main directions of regulatory action? Firstly, a regulatory shift towards market fairness has been one of the implications of technological change in the last two decades. In the pathway towards 5G, the industrial system requires conditions which are conducive to operator productivity. Mobile advanced services would appear from a market based on needs and demand. The market would define service

features, and operators would provide their implementation. Therefore, for a smooth functioning of such a mechanism, the concern for market fairness is necessary.

5. CHALLENGES AT COUNTRY LEVEL

This paper discusses the impact of 5G as disruptive innovation at the dimension of country level, in which standards and regulation are becoming the concern for policy makers (governments). It is a clear concept that the objectives of regulatory policies should eventually lead to support the welfare of a country. Yet, another classical concept of policies recognizes that the regulatory policies tend to be reactive to technological change (Ro & Kim, 1996). There is an explicit recognition that government is quite limited in the things it can do well, while policy should be concerned with such constraints (Nelson & Winter, 1982). Therefore, when technological change from 4G to 5G is predicted to be a disruptive change, a constructive anticipation is necessary.

We discuss the challenges for the country's policy maker as follows:

5.1. The Massive Emergence of Non-human Market

Reflecting on what has happened in the past two decades, the era of mobile high-speed data has been characterized by the importance of a service-driven perspective. The commercial value of an implemented technology would be centered on the types of new services and applications (Suryanegara & Asvial, 2013). There is co-evolution between technology and the market, in which both are exhibiting action-response under the continuous sequence of demand and supply.

A service-driven perspective would make the regulator focus on non-technical regulatory matters, while the technical matters will be given to the implementer of technology, i.e. network operator. For example, when the market is expecting advanced applications to support financial transactions, the regulator should not be concerned with the technology. The regulator should let the operators find a suitable technology to support such a demand. The regulator should focus on managing non-technical matters, such as regulatory coordination with financial institutions.

However, in the era of 3G and 4G, there is a clear condition that among all applications, the main targets are personal communications between humans. Therefore, it is plain to see that regulators drive their policies with the main orientation towards the support of personal communications. Examples of such concerns include the establishment of market fairness and subscriber privacy protection.

What if the market is not human? Disruptive innovation brings the consequence of new market value, in which 5G will certainly build a new market of non-human subscribers. There will be excessive growth of IoT and M2M applications, while personal communications would already have reached saturation level.

In short, policy makers should be aware of the implications of excessive growth of interconnected devices. A simple mathematical picture can be imagined as a number of devices connected with a human subscriber. In day to day life, one person may interact with his/her car, watch, air conditioner, vehicle, utensils, etc. 5G vision is to assist human lifestyle by connecting devices within a human's network, so that they can then be easily managed and maximally utilized. In such ecosystem, the machine-human connection is getting more intense and complex. Consequently, the issue of privacy and security are getting more important.

Another crucial issue appears to be that policy makers should deal with the emergence of various technological non-human platforms. A problematic aspect of the process of diffusion of new technological standards is how the regulator can ensure successful implementation of such

standards in the market. Along with the growth of connected devices, the number of technological platforms will also become diverse, which requires the regulator to treat them fairly and give similar opportunity within the market. In addition, the complexity of such market changes will also cause policy makers to consider a broader dimension of social and cultural factors.

5.2. The Security Standardization of Cloud Applications

5G will likely trigger profound cloud-based applications. The services which will emerge in the next decades are hardly imaginable. Many organizations, small and large, have embraced it because of the advantages it promises in terms of flexible cost structure, scalability, and efficiency (Sultan & Van de Bunt-Kokhuis, 2012). Cloud itself can be seen as a disruptive innovation, because the technology may change many of the traditional ways of delivering computing services to people and organizations (Sultan & Van de Bunt-Kokhuis, 2012).

However, in the market of Internet data communications, the circulation of data is easily leaked. When everything is based on cloud, consequently, the data security issue is becoming important. A security issue comprises many aspects, such as network security, perimeter security, and data security. At the global level, the standardization reference is listed in ITU-T Recommendation X.805 "Security architecture for systems providing end-to-end communications, Data Security Framework Rev1.0" issued by the Open Data Center Alliance (ODCA) (ODCA, 2014).

In data communications, the term "data life cycle" describes the data through the process of creation, storage, use, sharing, archiving, and destruction (ODCA, 2014). To obtain holistic data security end-to-end on a distributed data network, the ITU-T standards on security architecture uses X.805 models as shown in Figure 1.

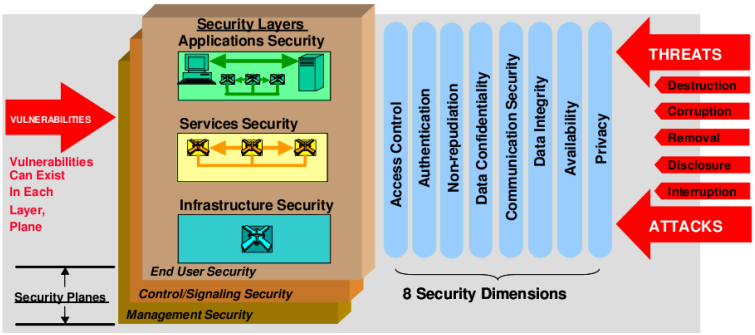

Figure 1 Security Architecture X.805 ITU-T (ITU-T, 2003)

The basic principle of the framework of a security system is to provide security for the entire application by considering the types of attacks (threats) and crack potential (vulnerabilities). Security system architecture framework is built on the concept of layers (layering) and field or section (plane). The concept is intended to obtain security end-to-end on each layer including infrastructure layer, service layer, and application layer. In general, ITU divides the security aspects into eight portions, i.e. *Access Control*, *Authentication*, *Non-Repudiation*, *Data Confidentiality*, *Communication Security*, *Data Integrity*, *Availability*, *and Privacy* (ITU-T, 2003).

The challenge for a national regulator is how to ensure the security framework on each level. Should a country simply adopt the global standard, or should they customize and develop their own? At the country level, standardization is concerned with the function of country as a member of ITU. Typically, a country would adopt an international standard to ensure the

market would be for the common good. However, in reality, national threats can differ country by country. National regulators should anticipate this by setting up their own framework.

5.3. Maximizing Opportunity of Local Standard and Industrial Development

One of the characteristic of disruptive innovation is against the mainstream. When global trend is the mainstream, local innovation may appear as the alternative. Windows of opportunity are opened, yet the challenge for the policy maker is to trigger developments to its own standard.

For example, 5G needs to be supported by enough energy resources (Andrews et al., 2014). There is opportunity to conduct research related to renewable energy, where it drives support for the 5G network. However, the most important long term challenge facing renewable energy remains economic, in which renewable cost is often greater than fossil energy (Andrews et al., 2014). Under such conditions, we may assume fossil energy as the mainstream energy resource, and renewable energy as the disruptive one. Successful R&D of renewable technology will eventually threaten such fossil energy. Therefore, a policy maker can drive its national research plan to engage in related R&D activities.

Why is the development of local innovation significant? There is a correlation between the empowerment of innovation and supporting the industrial environment of a country. Particularly for a developing country, they should grasp the opportunities provided by mobile technology development.

Industrial policies are the product of learning from technical opportunities and the relevant 5G technological framework based on that country's specific characteristics. Since regulators focus on telecommunications policy product, they need to cooperate with supporting institutions. Industrial policy should be linked to the science and technology (S&T) creators, because they are the knowledge generators in innovation building.

The profile of any mobile technological generation can be elaborated into issues regarding technological standards and service applications. Consequently, there is great opportunity for research activities to support service applications on top of technological standards. Such a greater opportunity will finally lead to more room for innovations. Meanwhile, a country can set up two streams of innovation building, i.e. first, contribution to an international standardization body (such as ITU), based on issues regarding technological standard implementation; second, collaborative research output can be directed to support the development of 5G-relevant service applications.

6. CONCLUSION

This paper has discussed the challenges emerging from 5G as a disruptive innovation. We focused on the area of standards and regulations at the country level. As a disruptive innovation, it is indicated that 5G technology will create a new market value of non-human users. Such a condition may challenge policy makers in any country to anticipate the relevant impact, in particular the complexity of multi-device technological platforms.

Subsequent challenges appear with security issues of cloud-based applications. Since 5G's latency will no longer be a problem, 5G service will enable the creation of massive cloud-based applications. However, national threats can be different country by country; therefore, national regulators should anticipate setting up their own frameworks and also complying with global standards.

Finally, 5G technological services would require many supporting technologies, for example renewable energy can be utilized to support future BTS. Therefore, we argue that local standard may appear as the alternative solution to mainstream technologies. The windows of opportunity are opened, yet challenge policy makers to trigger development of their own local standards. It

is signified that developing countries may utilize such opportunity to empower their industrial competitiveness.

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