早稲田大学における企業ビジネスと標準化教育

Corporate Business and International Standards Education at Waseda University

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This paper aims to focus on the standardization process and its consequences in the field of information and communication technologies (ICT), with a view to understanding the significance of the standardization in academia and inclusion to this subject in academic curricula. Particularly, we take the scenario of cellular communication industry and as an evolutionary technology we take CDMA (Code Division Multiple Access) as a case study. Game theory is chosen as a tool for analysis of the business decision of stakeholder of an innovative technology. CDMA's spread spectrum approach was unique. However, the good technology doesn't always win out. A good example is VHS ; which is successful and won out the market though technically inferior to Betamax. For the case of CDMA, we explain the case of good technological innovation, strategic management by the innovator and the role of standardization as a pre-requisite to win the market. We designed the game based on the scenario while a technology licensor (Qualcomm) simultaneously works as a product manufacturer and make a role overlapping with the licensee (Motorola, Nokia, Ericson etc). We also give a brief mathematical analysis with the Stackelberg leadership Game Model for the Qualcomm's Royalty and Chip business.

Keywords : Standard Education, CDMA, TDMA, GSM, Qualcomm, Motorola, Nokia, Ericson

キーワード : 標準化教育, CDMA, TDMA, GSM, クオアルコム, モトローラ, ノキア, エリクソン

1. Introduction

Cellular standardization process is good example to give education program to make students accustomed with standardization and its importance. This paper introduce the process and influence of standardization of CDMA (Code Division Multiple Access), the technology organized by Qualcomm in 2000. This paper also clarifies the importance of Game theory for the relationship of patent, royalty and standardization (Figure 1).

Figure 1. The relation of royalty business, standardization and game theory.

In 1978, Georse Cooper & Ray Nettleon published a paper¹⁾ suggesting spread spectrum as the ultimate solution for cellular system because of its highly efficient use of frequency bandwidth. But the commercial industry remained skeptical about the spread spectrum technique for mobile environment. Founded in 1985, Qualcomm begins working with CDMA, a unique digital wireless technology used by the U.S. military for secure communications²⁾. Before issuing the very first patent and start campaigning of CDMA by Qualcomm ; the GSM was already in a path of standardization in the European market. So, it was almost impossible to give a second think about CDMA for the European vendors. On the other hand, the TDMA was in the queue for a candidate of standardization in the US market. So, in spite of its true technological merit, it was not easy to catchup the cellular market for the Qualcomm's CDMA technology. However, the US standardization strategy is little bit different from that of Europe. In the US,

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the strategy is to encourage new technology besides standardization. The idea is that, if the technology is really better, then the customer will enjoy the best technology and advanced services as well as the US can sell their good technology to other countries. Qualcomm take the advantages of the US's standardization point of view ; as well as in continue to give persistent efforts to enter the global market.

Qualcomm is a company with difference compared to most of the IP Licensors companies. Qualcomm being a company formed with a collection of PhDs, the producing patent and collecting the royalty could be an obvious choice. In royalty collection, Qualcomm is the leading company in the telecomm industry since on an average about 5 percent of each CDMA mobile phone's cost goes to Qualcomm as a licensing fee^{3), 4)}. However, in addition to collect the royalty it extends its business in the form of manufacturing. The chip that they made inherently is the best since they know the CDMA better than any other company⁵⁾. The company do agreement with other company and one of the term of the agreement is not to disclose the detail conditions of the contract publicly. Among many innovative terms and conditions another proposal is whether the licensee company will use the Qualcomm's chip or not. This gives the Qualcomm two advantages. Firstly, it ensures the Qualcomm's chip sale. Secondly, it can predict the demand. However, if the Licensee Company does not agree with the mandatory chip purchase then Qualcomm cannot predict its chip market for that Licensee. With a series of innovative thinking both in business and technology Qualcomm established its CDMA as a supreme technology in the cellular industry in the Globe.

Standards are necessary for the wide adoption of new technologies in the marketplace⁶⁾. However, most of the cases the implementation of the standard requires the use of technologies that are protected by patents. The objective of a standard setting body (SSB) is to establish standardized technology that can be used widespread. But since the patent holder usually have commercial interest ; they try to push for the adoption of their own patented technology in the framework of the standard. So the patent holder can be benefitted immensely from royalties if the technology protected by their patent is accepted in the framework of standard by SSB.

The rest of the paper is organized as follows : We describe our proposed Game theory in section 2. In

Section 3, we give the mathematical elaboration of our formulated game with Stackelberg game model. Finally, section 4 concludes the paper with a summary and some scope of future work.

2. Proposed Game Theory

In this section, we formulate the game between two players. The first one is the company who is the inventor of new technology & issued numerous patents in favor of their innovation but since young company or new in the market and has little acceptance in the market. Particularly Qualcomm is considered in the scope of this paper as such player. The second players we consider are the company who already won the market with the existing technology with their previous product for a particular industry (cellular industry in this case) and have earned the brand value. Ericson, Nokia and Motorola etc are example for this player in the scope of this paper. This game model is based on the Stackelberg leadership model is a strategic game in economics in which the leader firm moves first and then the follower firms move sequentially. We present the mathematical explanation in section 3.

In general the technology inventor (company with IPs), technology licensee, are different entity and their role doesn't overlap. That is the inventor role is limited to producing new idea and earns patents for the sophisticated technology and the role of technology licensee is within the limit of marketing new technology, earn customer satisfaction and hence earn profit. However in case of Qualcomm it can be seen that there is overlapping the role of technology inventor/licensor/ company holding IPs and the role of technology licensee since besides IP Qualcomm is a chip producer as well.

In the matrix (Figure 2), the sample payoff values have taken to explain the benefits of players of the game. The players can choose their position freely. Qualcomm agreements proposal to the vendors had some unique features. One of them was "try before you buy" that is the vendors can agree to use the CDMA with a lower risk⁴⁾. If they are satisfied with the power and services of CDMA they can make the final agreement. The second offering was that Qualcomm will extend technical their support as well. So, we can formulate the following payoff matrix from the basic offer of Qualcomm. The payoff we use the unit value because of simplicity.

Figure 2 shows the choices and corresponding pay-

Strategy of IP Licensee/Equipment vender company	Strategy of IP Licensing company		
		License without Technical support	License & Technical support
	No agreement	$(-1, -1)$	$(-1, -2)$
	Agreement	$(1, 1)$	$(2, 1)$
	Once agreed Then backtrack & don't buy	$(-1, -1)$	$(0, -1)$

Figure 2. Payoffs vectors for the IP Licensor, and the Licensee

offs for the IP Licensor, and the Licensee while the role of Technology inventor/licensor/ company holding IPs and the role of technology licensee overlap with each other. The IP Licensing company has two choices either it can offer License and do not expands its capacity to offer the technical support. In this case it will have lower investment since it will be confined upon the intellectual paper work and innovation. The company in this case needs not concern about service. So, in this case if the manufacturers are not convinced with the potentials of the new technology, they will not go for the agreement. If Vendor does not enter in the agreement it will get a payoff of -1. It is because, it will have the possibility of losing the future market if other vendor become successful by using CDMA. The technology licensor on the other hand will loose the big partner and hence will have a payoff of -1. In other words, since the inventor company couldn't sell its IP/License it will have a negative payoff of -1. On the other hand by not buying the new technology and staying with the old technology the manufacturer fall on a risk of running business with the outdated technology which give it a negative pay off of -1. So, in Figure 2 both player payoff is $(-1, -1)$.

Now if the IP Licensing company prepared itself for rendering technical support as well to the Licensor, it need additional investment to expand its capacity. So, after offering both License with the technical support if the manufacturers do not convinced to do agreement it will have an addition negative payoff of -1 with results the payoff value for the player (Equipment vendor, Licensing company) = $(-1, -2)$. However, this after sell support offering will help to convince the manufacturer about the viability of the implementation of the new technology and increase

the chance of buying the license. These give the manufacturer an additional payoff to becoming the licensee of a new technology with results $(1+1, 1)=(2, 1)$. Another option is once agreed by the manufacturer to buy a trial version of the technology, later backtrack and don't convinced to go for the final contract. However, if technology itself is good and technological support by the licensor id up to the mark then the manufacturer will obviously not backtrack rather will go for the final contract. Similarly we can formulate the value for the case of other choices of the vendors depending on the two choices of the Licensor Company. With the forward deduction scheme⁷⁾ we can show than the agreement with the technical support is the win-win situation for both the IP Licensing company and the Licensee or the Equipment vendor.

3. Mathematical Analysis with the Stackelberg leadership Game Model for the Qualcomm's Royalty and Chip business :

After becoming licensee of CDMA, the manufacturer Ericson, Nokia etc. also started to produce patents for CDMA as usually big vendors/manufacturer do. When the licensee starts issuing patent then the royalty of the original inventor face patent conflict and revenue reduction problem. We do not go for the detail scenario of the applicable patents claim conflict (which usually end up with the law suit and arbitration). In this section we formulate the game based on this scenario of royalty decrease of the original licensor and the licensee when they issue some patent as well. We formulate the two stage stackelberg game where the Qualcomm is the game leader and the manufacturer (ex. Ericson, Nokia, etc) are the game follower.

The following shows the formulation of a simple Stackelberg game where we ignore some details. Firstly, we can model the utility function of the game leader, Qualcomm,

$$F_1(p1, n) = x * p1 + n^2 * c1 \quad (1)$$

Note : given the cost of each patent is $c1$, Qualcomm has to decide the number of patents to be applied(n), and the price charged for using a patent, i.e., $p1$. The total cost of Qualcomm, is given by

$$F_2(p1, n) = -x * p1 + n * c1 \quad (2)$$

" x " is the number of patents used by Ericson. The first part is the minus revenue, the second part is the cost of patent. n^2 means the cost of patent increases faster if Qualcomm files a lot of patents because it has to maintain a huge team of researchers and lawyers.

While the game follower, e.g., Ericson, its utility function is

$$F_3(x) = x * p1 + c2 * (n - x)^2 \quad (3)$$

The first part is the cost of using the patent, the second part is the cost of not using the patent. $(n - x)$ is the number of patents which are not from Qualcomm. Ericson has to do research to file these $n - x$ patents.

The cost of not using the patent increases faster than linear, since you have to put maintain a huge team of researchers to do research or file your own patent.

Then we can firstly solve the x as a function of $p1$ and n . Take the first-order of $F(x)$ to x , we have

$$p1 - 2 * c2 * (n - x) = 0 \quad (4)$$

$$x = h(p1, n) \quad (5)$$

Then take $x = h(p1, n)$ back to F_1 , and write

$$F_1(p1, n) = -h(p1, n) * p1 + n^2 * c1 \quad (6)$$

Then take the first-order of F_1 to $p1$ and n respectively, we can find the relationship of $p1$ and n . With this relationship of $p1$ and n and equation (1) we find the utility/ profit of the Qualcomm for its each business decision. Similarly, the manufacturer's utility can be calculated.

4. Conclusion And Future Work

This paper clarifies the standardization process of CDMA using game theory. CDMA standardization process is one of the example to give education of standardization. This scenario is easy to approach the understanding the meaning of the standardization. In this paper, we analyze the scenario of role overlapping of the licensor and licensee by game theoretic format. We particularly take few telecom giant Qualcomm, Ericson, Nokia, Motorola as player of our proposed game clarification. We also explain some reasons of the success of the CDMA and the role of Qualcomm and its standardization initiatives behind it. By focusing the importance of the standardization process and its consequences in the field of information and communication technologies (ICT), we stress the worth of inclusion of the standardization subject in academic curricula. Besides, we also exploit Game theory as a tool for study and analysis of the business decision of IP Licensee and IP Licensor. As a scope of future work, we have a plan to analyze in detail relationship of Industry, academia and standardization from both technological and economic perspective.

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