

○Kumiko Miyazaki (Tokyo Institute of Technology) , Kjartan Jonsson (Icelandair)

Abstract This paper seeks to explore the reasons behind KDDI's success and the key factors affecting 3G mobile diffusion. Of special importance are factors such as the technology adoption by users, different corporate and technology strategies of the operators especially regarding backward compatibility and standards. Data has been obtained by conducting a survey of mobile phone users and a set of interviews with key people connected to the mobile sector in Japan. Subscriber and company statistics, brochures have also been analyzed. We conclude that success in gaining 3G customers depends, to some extent, on technology strategies related to backward compatibility, choices of standards and timing of standards changes.

1. Introduction

Over 2 years have passed now since NTT DoCoMo started its 3G FOMA service based on the WCDMA standard and over 1 1/2 years since KDDI started its 3G service based on the CDMA2000 standard in Japan. Although it is still in the early stage of the technology diffusion process, the situation provides an interesting research topic, a latecomer and small player on the market, KDDI is doing much better than the first mover and market giant, DoCoMo. Figure 1 shows the 3G subscribers growth in Japan. In this paper, the Japanese 3G mobile is analyzed, especially focusing on the two successful carriers – DoCoMo and KDDI. Section 2 presents a theoretical framework and the methodology. In the following section, background to the transition from 2G to 3G is discussed. Then a survey carried out to analyze the adoption pattern of users is described. As a last step, the technology strategies of the two operators DoCoMo and KDDI are examined. The findings obtained from the survey, case studies are analyzed and some conclusions are offered.

2. Theoretical Framework and Methodology

In order to develop a conceptual framework, the following research questions were constructed: *1) Why has one company (KDDI) been much more successful than DoCoMo in gaining 3G customers? 2) Do differences in choice of standards and strategies towards backward compatibility have effects on the 3G services diffusion? 3) What are the main differences in the two companies' technology strategy and how do they contribute to 3G diffusion?*

Diffusion theory attempts to characterize the speed and the rate at which innovations spread in the economy. Usually, diffusion of many technological innovations shows an S-shaped pattern based on a logistic model. Diffusion theory has to embrace both factors that influence the demand of potential adopters and the factors that influence the supply of innovations. Based on this, we propose a model of 3G diffusion.

1. Firstly, on the supply side, different *technology strategies of the key players such as operators, handset manufacturers* have an effect on diffusion. These in turn are influenced by path dependence and technological, organizational competences. Strategies towards radical, incremental innovations have to be considered.
2. Secondly, on the demand side, we need to consider the factors that are expected to influence technology adoption by users.
3. *Standards and standardization* in the economics literature provide a basis for understanding the technology diffusion environment when multiple standards coexist and how standards have an influence on markets, competition, and innovation.

In this paper, an analysis is made by focusing especially on the role of technology strategies of the operators and the adoption by users. After defining the problem and conducting literature studies we conducted a preliminary user survey and a series of interviews with key people in industry, government and academia. Subscriber and company statistics, brochures were also analyzed. The user survey was carried out at Tokyo Institute of Technology campus in late 2003. 23 Interviews were conducted from October 2003 to January 2004.

3. Evolution towards 3G Technology and Services

Second generation (2G) mobile telephony systems were developed and deployed in the early to mid-1990s, in response to the rapid growth in first generation cellular subscribers. 2G systems were distinguished from the 1G cellular systems by the use of digital signal transmission techniques and some operated on a higher frequency band. It can be said that innovation in mobile phones is generally *incremental*, however when the technology leap is significant, such as the leap from 2G to 3G technologies, the innovation in handsets and network technology is closer to a *radical innovation*. Evaluating this in respect to 3G upgrade for the two operators is essential. Since the early 1990s, the ITU has been supporting an international effort to develop the advanced third-generation (3G) mobile telecommunications service. To that end, the ITU identified spectrums and developed technical standards for International Mobile Telecommunications 2000 (IMT-2000), the official name for 3G services. Today, two major 3G standards approved by the International Telecommunications Union (ITU) are competing to become the dominant global 3G standard. They will initially be incompatible with one another, but they are expected to eventually attain mutual compatibility. One of the standards - WCDMA - was developed partly by DoCoMo, the other - CDMA2000 - was developed by Qualcomm, a US company. In 2003, a majority of service providers pledged adoption of WCDMA in Japan (DoCoMo, Vodafone), Europe, parts of SE Asia and parts of N America. Major providers in N America, China, Japan (KDDI) and other parts of SE Asia pledged to adopt CDMA2000. The standard is licensed by Qualcomm and KDDI uses this technology. In the mobile standards battle, technological superiority is not necessarily a key success factor.

4. Mobile Phone User Survey

To gather information on the *technology adoption pattern* of 3G mobile users, a preliminary survey was conducted, whose results are compiled and explained in this section. The aim of the survey was to identify a set of factors that influence the diffusion process related to user adoption. Our survey was conducted on Tokyo Tech's campus and the respondents were all Tokyo Tech students. We fully realize the limitation of the survey since the sample size as well as the background of the respondents is limited. However, we should be able to obtain valuable information on the adoption patterns of users in a targeted segment. 108 responses were collected in the first phase. We will only present the findings from the questions which are directly connected to the theme of this paper.

4.1 Survey Results

Question : What are the most important factors in choosing a mobile phone operator?

39% of KDDI's customers in the sample mentioned *Price of Telephone Calls* as the most important factor, while 22% mentioned *Price of Phone* etc. Customers of KDDI and Vodafone are very much concerned with price, while DoCoMo's customers are most interested in the operator's image. *Price of phone* is quite important for the smaller operator's customers but not so much for DoCoMo's customers. This implies that the phones(handsets) are rather expensive. *Variety of services* seems to be more important than *quality of services* in general. The highest factor is DoCoMo users *operator image* (3.97), followed by KDDI's *price of phone calls* (3.78).

Question : If you are using a 3G phone, why did you change to it from a 2G phone?

This question is one of the key questions of the survey. Out of the 4 factors, *Better Voice Quality* was only mentioned by two respondents as first choice and seldom as other factors. All other factors were mentioned often, so *Better Voice Quality* does not seem to be important for 3G users. However, this is regarded as one of the strongest selling points for 3G technology. FOMA users made similar choices and showed clear preferences on *Faster data* and *services*. KDDI 3G users had more diverse preferences, divided between *No choice*, *Better services* and *Faster data speed*.

Drawing conclusions from this, 3G customers are most interested in *Faster data*, much more than *Voice quality* and somewhat more than *New services*. The distinction between DoCoMo and KDDI users is clear. DoCoMo users chose 3G because of *Faster data* or *New services*. On the other hand, just over 50% of KDDI's 3G users were 'upgraded' without intentionally choosing it, in other words they had no choice. But it is also important to note that the rest of KDDI's 3G users chose 3G because of *Services* or *Faster data*. When the phone bill for 3G users are compared, the difference is very clear. What this probably shows is that KDDI has upgraded its customers with little, if any, increase in ARPU(Average Revenue per User). DoCoMo's 3G users however, are spending significantly more money. This is partly because the FOMA service is still quite expensive and probably catering to tech-geeks or heavy users. This is likely to change when the number of users increases:

5. Comparison between the Technology Strategies of DoCoMo and KDDI

In the development of 3G wireless standards, most operators have only been observers of the process. The major exception to this is DoCoMo, with its massive R&D competence.¹ There is a huge difference in R&D expenditure between DoCoMo

¹ R&D expenditure was 126,220 million yen for the fiscal year 2002-2003

and KDDI. Large differences in capital expenditure are evident as well. DoCoMo is spending 46% more per customer on the 3G upgrade than KDDI. It can be argued that KDDI already paid for part of the 3G upgrade by changing from PDC to CDMA network. But the difference is still huge and likely to have a large impact on the different break even points for 3G investment of the carriers. Information on this issue is, however, understandably classified.

DoCoMo begun doing research on 3G technologies and standards very early on (in 1992) and was able to build a strong technical competence in this area at an early stage. DoCoMo was the first operator in the world to start WCDMA services, named FOMA, in September 2001. 500 thousand subscribers were expected in the first 6 months but eventually there were only 150 thousand. After overshooting FOMA subscription estimation a few times after that subscribers reached 1.9 million in January 2004. DoCoMo considers that FOMA is a part of a long evolution (PDC 9.6 kb>PDC packet 28.8 kb>FOMA 384 kb) and backward compatibility has a history at DoCoMo, all the way from Analog to PDC to PDC Packet. But sometimes there is a 'jump' between generations; this is what is happening with FOMA which was a radical innovation, according to DoCoMo interviews. So in this case backward compatibility was not chosen, dual mode handsets were thought of and in fact one handset (PDC/WCDMA) is available but it is not popular. According to DoCoMo, it was not ready to speed up diffusion by subsidizing handsets more than is done today. Their strategy was not to lose money by upgrading customers into FOMA; however FOMA is clearly DoCoMo's network for the future. FOMA uses Circuit Switched network (ATM based)² as the core network. The reason for this choice is largely the initial investment in ATM technology in the 1990s at DoCoMo, according to the interviews. It may have seemed an economical decision at the time, but with developments in IP technology and networks, IP networks are cheaper today than ATM.

The 'adoption' curve for FOMA started to go up in Sept 2003 because of better handsets with better batteries that were marketed at the time. This meant that FOMA phones finally became compatible with PDC phones in the most important features.³ Here *backward compatibility* has been reached eventually regarding all services and features, but it took 2 years. NEC, Matsushita, Hitachi and Ericsson are working on FOMA network for DoCoMo. Many bugs were found in the FOMA services in the first years but today, after 2 1/2 years of services the infrastructure is finally quite stable. New series of handsets have been coming out in 2004; those handsets were even more advanced than PDC handsets in size, ability and weight. The FOMA diffusion has been slower than expected. It is difficult to say at this time what they could have done differently, but it seems that one thing at least would have been to delay the deployment of FOMA. It was way too early technically and way too early in terms of customer needs. Even today killer applications such as Video Phones have yet to take off.

According to KDDI interviews, there was a large debate inside the company regarding the 3G standards choice in 1998. At the time there were many problems related to competition with DoCoMo. DoCoMo was very strong and influential, and many companies, such as leading handsets and networks manufacturers were strongly linked to NTT and DoCoMo. It seemed these companies did not care much about the smaller telecom companies but always waited for guidance from NTT. NEC and Matsushita/Panasonic were the companies most strongly linked to NTT, so KDDI decided to try to connect with smaller vendors, such as Hitachi and Kyocera. At the time those companies were not advanced in handsets or networks but have gradually become more competitive, partly as a result of the experiences KDDI and others have given them, according to the interviews at KDDI. Because of those and other problems with the domestic market, KDDI opted for a foreign network and technology vendor. Previously they had worked with Motorola and used Motorola's network equipment. KDDI wanted to be independent from DoCoMo in the next generation of mobile phone systems.⁴

For these reasons, the strategic choice was made to go with American technology (Qualcomm) and a network vendor (Motorola). Lucent was also an option, but KDDI's previous connections with Motorola were important. Handsets would come from the 'smaller' players in the Japanese market. Motorola, being a large technology exporter, was ready to work with Japanese companies. The choice of CDMA2000 for 3G was therefore a strategic decision at KDDI which differentiated the company from others on the Japanese market. The technology was also American which could play well politically later. DoCoMo's WCDMA is more related to Europe and of course it is a licensed DoCoMo technology.

Initial investments transferring from PDC to CDMA were high since it was a radical innovation, but when they went through version ups, it went smoothly since they were incremental innovations. Once the CDMA network was set up, further upgrades were also relatively simple and fast (faster than competitors). As a special promotion in encouraging customers to migrate from PDC to CDMA, KDDI offered higher quality handsets (CDMA) at lower prices than the comparable PDC ones. There were many challenges; technological know-how required is totally different between PDC

² Asynchronous Transfer Module, a connection switching technology

³ Battery life has reached 300 hours (standby) in the new models in the market from Jan 2004. Weight is down to 100 grams and camera quality has improved

⁴ According to interviewees at KDDI

and CDMA. DoCoMo and Vodafone are now facing these same challenges of new technology as KDDI did in 1999. But KDDI has had 4 years to build competences in CDMA technology. Concluding the standards strategy discussion it can be said that: KDDI decided to go for CDMA 2000 mainly as a *competitive strategy* since it wanted to differentiate itself from DoCoMo (and J-Phone/Vodafone). In some ways it was also a tactical *technological strategy* - there would likely be less technical failures (the technology not as 'revolutionary' as WCDMA) and KDDI would not have to be subject to a standard developed largely by one of its competitors (DoCoMo)

When the customers upgraded from cdmaOne to CDMA2000 1x many of them did not even know about the upgrade. KDDI believes that customers are interested in services and price. The key factors are what kinds of services are offered and how much they cost. Diversity is more important than quality in services. The survey findings also point to the same trend. KDDI chose the strategy of backward compatibility. This issue was debated seriously within the company and considered it would be an important factor for success. Shortly after the upgrade to CDMA2000 1x, handset prices for the new and the old technology were set almost the same, encouraging users to go for the new phones with better features. Phones were (and still are) heavily subsidized by the operator. The KDDI 3G phones have usually been sold for less than ¥10,000 (when real price is over ¥30,000) so they were always much cheaper than DoCoMo's FOMA phones. .

Conclusions

It appears that KDDI chose the right timing by switching from PDC into CDMA in 1999, allowing the company longer time to adapt to the new standard and hence experience an easier 3G upgrade path than DoCoMo. KDDI has both changed from PDC to CDMA and from CDMA to CDMA2000, so the company was able to break out of technical lock-in. Transfer from PDC to CDMA was a radical innovation, while the move from CDMAOne to CDMA2000 was more of an incremental innovation. By choosing the strategy of backward compatibility, KDDI was able to gain from network externality. At the same time DoCoMo is certainly more locked into the WCDMA standard with its own technology and much greater level of R&D and overall investment. DoCoMo is also locked into its ATM core network and uses it for FOMA as well as other mobile systems while KDDI could go directly into a more cost effective IP network.

In 1998 when the decision to use CDMA was taken, no-one knew that CDMA2000 would become so successful, in fact most analysts expected WCDMA to dominate the world. But there were other views also, including some at KDDI, where there were greater expectations for CDMA2000 and that it might compete aggressively with WCDMA. These circumstances are related to the notion of technological expectations.

In relation to this, it can be said that success in gaining 3G customers depends, to some extent, on standards choices and timing of standards changes. DoCoMo chose an *offensive* strategy to be a technical leader and pioneer, while KDDI followed a more proven path. There is a lot of investment in being a technological leader and once the products on the market don't sell (like in WCDMA network and handsets) it can be quite costly. Finally there is no so called "killer application" data intensive service that really drives diffusion for 3G in the Japanese market. Until something like that materializes, there is simply limited need for the data speed that 3G offers.

Acknowledgements The authors wish to thank the people from industry, academia and government interviewed for their kind cooperation. We would like to acknowledge the support of the Ministry of Education in several phases of our studies.

REFERENCES

- Freeman, C. and Perez, C. (1988), "Structural crises of adjustment, business cycles and investment behavior" Technical change and economic theory, Pinter, London
 Jonsson, K. (2004), "Key Factors Affecting 3G Mobile Diffusion in Japan", MSc Thesis, Tokyo Institute of Technology
 ITU (2002), "Internet for a mobile generation" ITU Internet Report Series "
 Mobile Business Hakusho (White Paper) 2002, Shoueiisha
 Rogers, Everett M. (2003), "Diffusion of innovations" 5th ed. Free Press, New York
 Rosseger, G. (1996), "The Economics of Production and Innovation", Third Edition, Butterworth Heinemann, Oxford

Figure 1: Subscriber Growth in Japan, 2002 to 2003

