THE UNIVERSITY
of EDINBURGH

This thesis has been submitted in fulfilment of the requirements for a postgraduate degree (e.g. PhD, MPhil, DClinPsychol) at the University of Edinburgh. Please note the following terms and conditions of use:

The co-evolution of an emerging mobile technology and mobile services

A study of the distributed governance of technological innovation through the case of WiBro in South Korea

Jee Hyun SUH

Doctor of Philosophy
The University of Edinburgh
2014

Declaration

I hereby declare that this following thesis is my own work and that, to the best of my knowledge, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institutes of higher learning, except where due acknowledgement is made in the text.

July 2014

Jee Hyun Suh

Abstract

This thesis is a study of the development and uptake of an emerging infrastructural technology: the mobile Wireless Broadband technology and service known as WiBro in South Korea, and Mobile WiMAX internationally. WiBro has emerged through a national development effort since the early 2000s. The commercial service was launched in 2006. However, uptake fell far below initial expectations, only succeeding in niche markets. This study was motivated by concerns about the perceived gulf between development and diffusion and the 'failure' of WiBro. However, this study seeks to go beyond the technology-driven perspective that informs conceptions of diffusion gap: it aims to explicate the sociotechnical factors leading to such a gap.

This study draws on Science and Technology Studies (STS) and in particular the Social Shaping of Technology (SST) perspective, which provides tools to scrutinize the interactions among the various interests and factors involved in the process of technological innovation. The SST perspective goes beyond approaches that treat technology as a static object to be developed and diffused. It provides tools to examine the complex and dynamic forces that develop technical capacity towards particular forms and uses. The 'social learning' perspective extends SST and provides concepts to explore the changing dynamics over multiple cycles of innovation. Here, Jørgensen's concept of 'development arena' helps examine the interlinked, yet dispersed and multiple spaces in which differing goals, motivations and strategies of innovation players together shape technological innovation.

Through comprehensive analyses of a longitudinal study of WiBro, a broader view of the process and the outcomes of technological innovation have been achieved. Rather than viewing the technology as a stable object that would progress in a linear manner through the stages of design, development, and diffusion, it has focused on the process of shaping of WiBro through multiple cycles of innovation. Several *arenas* of innovation were identified as diverse players sought to align their interests towards exploiting the resources, capacities, and tools for innovation that seemed to be available. In these spaces, conflicting and yet coevolving dynamics were observed: one involving coordination through alignments of multiple interests, and

the other incorporating tensions and misalignments among the differing concerns, aims and commitments towards the innovation. The complex dynamics involved a multi-level game where the collective actions among the innovation players and their individual strategies diverged to a degree. Furthermore, changing contingencies, linked to shifting choices of innovation players, resulted in the deviation of the innovation from the initial visions and aims.

The study thus illustrates the outcomes of highly divergent interactions at play in innovation process and the mutual enrollment efforts of players that constituted the *distributed governance of innovation*. Here the complex interplays among the innovation players involved in multi-level games produced a gap between the generic vision and the actual uptake of WiBro. Changing contingencies, especially linked to broader and evolving structures and relations - brought about the re-shaping of the generic vision of WiBro. This research therefore suggests the concept of the 'distributed governance of innovation' as a new mode for governance: that accommodates not only differing knowledges and interests but also the shifting choices and visions through the various cycles of technological innovation. The boundary of social learning is thus extended to incorporate diverging choices over time and across the multiple spaces of innovation. Its implications for policy include achieving reflexivity by incorporating into the policy framework the learning process that takes place as the innovation players go through the varying stages and cycles of technological innovation.

Acknowledgement

Table of Contents

List of Tables

List of Figures

Abbreviations

2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
4G	Fourth Generation
ADSL	Asymmetric Digital Subscriber Line
APEC	Asia-Pacific Economic Cooperation
ANT	Actor-Network Theory
ARPU	Average Revenue Per User
BWLL	Broadband Wireless Local Loop
CDMA	Code division multiple access
CNN	Cable News Network
CTA	Constructive Technology Assessment
CTO	Chief Technology Officer
DTV	Digital Television
DMB	Digital Multimedia Broadcasting
ETRI	Electronics and Telecommunication Research Institute
EVDO	Enhanced Voice-Data Optimized or Enhanced Voice-Data Only
GHz	Gigahertz
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HHI	Hyundai Heavy Industry
HPi	High-speed Portable Internet
HSDPA	High-Speed Downlink Packet Access
IEEE	Institute of Electrical and Electronics Engineers

IMT2000   International Mobile Telecommunications 2000

IP   Internet Protocol

IPTV   Internet Protocol television

IPR   Intellectual property

ISM   Industrial, Scientific and Medical

IT   Information technology

ITU   International Telecommunication Union

ITU-R   International Telecommunication Union-Radiocommunication

Kbps   Kilobits per second

KCC   Korea Communications Commission

KICS   The Korean Institute of Communications and Information

KISDI   Korea Information Society Development Institute

KMI   Korea Mobile Internet

KT   Korea Telecom

KTF   Korea Telecom Freetel

KRW   South Korean Won

LAN   Local Area Network

LG   Lucky Goldstar

LGT   LG Telecom

LTE   Long-Term Evolution

LTE-FDD   LTE-Frequency Division Duplex

LTE-TDD   LTE-Time Division Duplex

MC-   Multiple Carrier-Time Division Multiple Access
TDMA

MC-   Multiple Carrier-Self-Organized Time Division Multiple Access
STDMA

MHz	Megahertz
MIC	Ministry of Information and Communications
MIMO	multiple-input and multiple-output
MLP	multilevel perspective
MMS	Multimedia Messaging Service
MSIP	Ministry of Science, ICT, and Future Planning
MVNO	mobile virtual network operator
NARS	National Assembly Research Service of Korea
NTT	Nippon Telegraph & Telephone Corp
OFDM	Orthogonal frequency-division multiplexing
OFDMA	Orthogonal Frequency-Division Multiple Access
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal digital assistant
PG	Project Group
PLC	Power-line communication
PMP	Personal Multimedia Player
PSS	Personal Subscriber Station
QoS	Quality of Service
RAPA	Korean Radio Promotion Agency
RFID	Radio-frequency identification
R&D	Research and development
SKT	SK Telecom
SNM	strategic niche management
SST	Social Shaping of Technology
TDD	Time-Division Duplex

TD-LTE	Time-Division Long-Term Evolution
TDMA	Time division multiple access
TDX	Time Division Exchange
TT	technology transition
TTA	Telecommunications Technology Association
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USTR	United States Trade Representative
u-IT839	Ubiquitous IT839
VoD	Video on Demand
VoIP	Voice over Internet Protocol
WCDMA/ W-CDMA	Wideband Code Division Multiple Access
WiBro	Wireless Broadband
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WLL	Wireless Local Loop
WMAN	Wireless Metropolitan Area Network

Chapter 1. Introduction

1.1 Aims and motivations

The research was initially rooted in a broad concern about how to address uncertainties in technological innovation. Having been introduced to Science and Technology Studies through the master's program at Edinburgh, I was fascinated and to an extent shocked by the views offered by the Social Shaping of Technology perspective (MacKenzie and Wajcman, 1985; Williams and Edge, 1996). It broadened my mind to look more deeply into the problems linked to technological innovation in society. At the same time, I aimed to find ways to better manage technological innovation in the face of uncertainties. This goal, however, seemed to suggest additional challenging issues and tasks in linking the social shaping of technology (SST) perspective with practical approaches and solutions to technological innovation.

Upon searching for a case to study around 2008, I came across the national success story of a wireless broadband technology in South Korea that was simultaneously facing a degree of uncertainty with regard to market adoption. WiBro (named after Wireless Broadband) had been developed and promoted through a national IT strategy (IT839) with the specific aim of reaching technological leadership by securing "home-grown" technology. As the technical specification of WiBro was further promoted as a global standard for mobile communications in 2007, it was regarded as an unprecedented success for South Korea through technological innovation (Chu, 2007). Yet, this promising technology carried a degree of uncertainty in its timely uptake in the domestic market. Despite the service launch in the Korean domestic market as the world's first wireless broadband service based on a global standard in 2006, the rate of service adoption during the 2 years of commercial roll out remained far below initial expectations.

The uncertainties in service adoption in South Korea, vis-à-vis the promises that had been heightened by global standardisation, were then largely framed as a problem of diffusion to be overcome. Especially in relation to the successful outcome of innovation efforts through government coordination and global standaradisation,

1

growing voices requested additional policy measures to promote diffusion and to vitalise the market for WiBro (Hong, 2007; Yun, 2007). However, ongoing debate ensued about whether the technology would still be viable for a wider diffusion in the longer term as it competed with and complemented other evolving mobile-communication technologies.

This is when my research gained momentum. I recognised the status of WiBro as in need of certain remedies for wider commercial uptake through policy measures, industry efforts, and perhaps most, to overcome the problem of diffusion. Critics, analysts, and government researchers suggested various causes. They variously diagnosed issues such as limited service coverage and poor device line-up as the main causes for the sluggish adoption of WiBro in the domestic market (Kim, 2009d; Paik et al., 2009). Furthermore, many argued that the biggest disadvantage of the current WiBro service was the failure to provide an outstanding application (ROA, 2008). An outstanding application such as voice support through Voice over IP (VoIP) would be key to competing with existing and evolving mobile-communication technologies such as high-speed downlink packet access (HSDPA). However, such diagnoses did not bring about immediate remedies or action to overcome the problem of diffusion. In fact, many of the remedial suggestions seemed to carry a degree of conflict and dispute among the diverse interests involved in the development and implementation of WiBro.

The future seemed uncertain in how the conflicts and disputes would eventually be settled to bring about a solution for domestic implementation. Based on the SST perspective (MacKenzie and Wajcman, 1985; Williams and Edge, 1996), this research aimed to elucidate a holistic picture of WiBro that would explain what had shaped and is shaping the technology and the services to the current mode of design and use. Rather than tracing fragments of causal relations, I aimed to describe the interactions involved in the shaping of the WiBro technology and services. The SST perspective, however, further emphasises future uncertainties: the unpredictability and serendipity of social and technical outcomes of innovation (Williams, 2006). Such a grounding seemed crucial, especially in relation to an ongoing process of technological innovation and its societal uptake. Although disputes arose in the ways

and legitimacy of further promoting WiBro in the domestic market, the fundamental task seemed to be to bring about realisation about how to deal with the uncertainties and the contingencies in the process of shaping the technology and the services. Therefore, this research was set for the study of the evolution of WiBro service through the development and uptake of an emerging telecommunication technology.

1.2 Overview of WiBro

Next generation mobile communication service

WiBro is a portable high-speed Internet technology and service developed by the telecom industry, manufacturers, and research institutes in South Korea. Commercial WiBro service was first introduced in the Korean domestic market in June 2006. WiBro was based on a technology developed by Samsung and the Electronics and Telecommunication Research Institute (ETRI): High-speed Portable Internet. The development of HPi was carried out through a collaborative R&D programme coordinated by the Ministry of Information and Communication (MIC) and funded by telecommunications-industry vendors and network operators. The industry characterised High-speed Portable Internet (HPi) as a technological innovation leading to next-generation mobile communications, adopting the orthogonal frequency-division multiplexing (OFDM) scheme, considered to characterise mobile technology "beyond IMT2000 (3G)" (Cho, 2003). WiBro service to be deployed in the Korean domestic market was initially characterised by low to medium speed mobility and high-speed data access enabling multimedia communications. WiBro was designed to be implemented with various mobile-communication devices such as mobile phones, Personal Digital Assistants (PDAs), Handheld PC (HPC), and laptops, providing 1 to 3 Mbps of upload and download speed while on the move (at 100~120 Km/h).

International standard

WiBro is a service profile to a global standard internationally known as Mobile WiMAX. Worldwide interoperability for microwave access (WiMAX) is a telecommunication technology that provides wireless broadband, based on the Institute of Electrical and Electronics Engineers (IEEE)802.16 standard. WiBro was

standardised by the Telecommunications Technology Association (TTA) of Korea in 2004, and through the process of standardisation, TTA reached an agreement with the IEEE802.16 group on harmonising the TTA standard for WiBro with IEEE802.16 standard. In the course of the process of globalisation, the South Korean MIC had to clarify the positioning of WiBro in relation to WiMAX as "the service name for Mobile WiMAX in Korea" on 29 July 2004 (Oh, 2009; WimaxForum, 2006). In 2007, WiBro (Mobile WiMAX based on IEEE802.16e-2005) was approved as the sixth IMT-2000 third-generation (3G) telecommunications standard by the International Telecommunications Union (ITU). In 2012, WirelessMAN-Advanced, evolving from the IEEE802.16e, based on 802.16m-2011, was specified as the standard for IMT-Advanced, the next-generation global wireless broadband communications by the ITU in 2012, along with LTE-Advanced evolving from Global System for Mobile Communications (GSM) (ITU, 2012).

Key issues

In the early years of technological development, the developers and service providers regarded WiBro as 3.5G technology or pre-4G as it is based on key technologies required by 4G, namely OFDM and multiple-input and multiple-output (MIMO). Also, WiBro, with an advanced version called WiBro Wave 2, could realise, in theory, a maximum data-transmission speed of 37.44 Mbps for download and 10.08 Mbps for upload. Such performance by WiBro was then compared to that of the data-transfer speed required by 3G (1Mbps) and 4G (100Mbit/s).

However, since the launch of its commercial services in Korea, the commercial uptake of WiBro service fell far below initial expectations. Subsequently, much dispute ensued about the success or failure of the policy drive towards the development and the commercialisation of WiBro. During its commercial deployment, it faced challenges from the rapid evolution of HSDPA as mobile operators in Korea implemented 3G mobile-communications service based on HSDPA. HSDPA is the 3G successor to GSM, based on the Universal Mobile Telecommunications System (UMTS) and was increasingly viewed as 3.5G. By the year 2009, HSDPA could reach downlink speeds up to 7.2 Mbps. Although

challenged by the competition in evolving mobile-communications technology in the emerging market, WiBro faced operators' choices of positioning WiBro as a complementary network and service for the existing and evolving mobile infrastructure.

The Korean government prepared and implemented various measures to promote WiBro service in the domestic market, especially by applying a series of 'WiBro vitalisation policies' to promote what had generally been considered a "home-grown" technology. The Korea Communications Commission (KCC), succeeding the MIC after 2008, allowed the deployment of VoIP service to enable the service providers to bring voice services to WiBro (Choi, 2009). Also, the government encouraged partnerships among government and private organisations and industry to develop and devise new services that would spur the commercial uptake of WiBro.

However, to date WiBro service has failed to meet initial visions and expectations. In the South Korean domestic market, WiBro service is sustained through a relatively small portion of service provided as mobile wifi. The service has largely been positioned as a complementary service to existing 3G and LTE networks, aiming to distribute the rapidly increasing data traffic. As of July 2013, the number of subscribers were 1,039,289, seemingly reaching stagnation (MSIP, 2013b)

Who are involved?

The major contribution to technological development of WiBro came from the collaboration between ETRI, a government research institute, and Samsung. HPi, the technology adopted for WiBro service, was developed through a national R&D programme (2002--005) coordinated by MIC through ETRI, major fixed-line and mobile operators funded and participated in the R&D programme. WiBro, as one of the leading advanced-telecommunications services, was also supported and promoted by the government's IT policy named IT839, initiated in 2004 and later renamed u-IT839 ('u' stands for ubiquitous).

The standardisation of WiBro (initially named Portable Internet) was also actively pursued through TTA, the nongovernmental organisation for information and

communication technologies (ICT) standardisation in Korea. The standard setting of Portable Internet was coordinated by MIC, aligned with policy decisions in 2002 to use the 2.3GHz frequency band for Portable Internet, based on a single standard to be set through TTA. The inaugural meeting of the Project Group for the standardisation of Portable Internet was attended by 235 individuals from 52 organisations.

In 2005, three operators—KT, SKT and Hanaro Telecom—were granted licenses for WiBro service on the 2.3GHz frequency band. SKT and KT remained the two operators of WiBro to date. Hanaro Telecom returned its license a few months after the license was granted. Despite multiple attempts by the Korean government to bring about an additional mobile operator for WiBro service, attempts have failed as of June 2014. WiBro operators have collaborated with other industry players who have traditionally been in the mobile-communications and fixed-line broadband Internet fields, as well as in other industries, as they sought to develop mobile handsets, platforms, applications and other convergence services.

1.3 Research questions

The objective of this research was initially driven by an aim to examine how a collectively driven, large-scale technological innovation could meet or respond to an evolving user environment. Having encountered STS, and in particular the SST perspective, however, I have come to pay particular attention to uncertainties and contingencies, and how they were addressed vis-à-vis efforts to coordinate interactions towards a particular vision. Based on the aims, motivations, and objectives of this research, as discussed above, the research questions were formulated to address the complex process of a lifecycle of innovation: from design to use and vice versa. First, an inquiry emerged about how the WiBro technology was conceptualised, designed, and developed. The second question extended the scope of this inquiry to include the process of deployment of WiBro services while addressing the gap between the initial visions of innovation and its actual commercial uptake. The third question aimed to bring a holistic view of the lifecycle of WiBro by examining how WiBro services evolved.

RQ. 1. What are the dynamics that led to the design and development of the emerging WiBro technology?

 - How did alignments among innovation players emerge and evolve towards the design and development of WiBro?

RQ. 2. How were WiBro services deployed, and what caused the gap between the initial visions of WiBro and its commercial uptake?

 - What choices did innovation players make and how did they interact towards the commercialisation of WiBro, and how did WiBro services evolve?

RQ. 3. How did WiBro services evolve, and how and to what extent could the gap be mediated?

 - How did the dynamics of innovation differ through the stages of technological development and uptake, and how should the 'gap' be addressed?

The first research question guided me to look into the processes of WiBro design and development, where the initiative of developing a home-grown technology took place and was carried out. I sought to examine how initial visions and alignments formed and evolved to drive the design and the development of WiBro. As WiBro had been pursued through a national-scale project involving a diverse array of innovation players, it seemed important to follow how those interested gathered and mobilised to develop WiBro, and how the interactions among the diverse interests drove WiBro towards innovation.

The second question points to the gap recognised in the commercial uptake. Despite the large-scale initiative towards technological innovation, the commercial uptake of WiBro deviated markedly from initial visions and expectations with regard to market diffusion. The question thus established a way to examine interactions among the diverse players that led to shifts and changes from the initial choices, vis-à-vis changing environments during the process of commercialisation. I aimed to consider

how the varying choices and their interactions during the process of innovation resulted in the current mode of service adoption of WiBro and how, in turn, the mode of service uptake has further shaped the innovation of WiBro.

Last, the question inquired about how WiBro services evolved. By examining how the services evolved and are evolving, I intended to examine what filled the gap between initial visions of innovation and commercial outcome. The gap was largely the problem of market diffusion of WiBro in South Korea. Much dispute arose about the role of policy in further promoting WiBro service in the South Korean domestic market. Certain measures were taken at the policy level, yet failed to bring about significant changes to its current status. Nonetheless, WiBro service has evolved. By applying the concept of the coshaping of technology and society, I aimed to reinterpret what has been framed as a 'gap'.

1.4 The organisation of the thesis

This thesis is comprised of eight chapters including this chapter as an introduction. This section introduces the structure of this thesis with a brief summary of each chapter.

Following this introductory chapter, Chapter 2 presents a review of the relevant literature. There, I discuss theoretical and analytical perspectives in relation to the problems briefly raised in Chapter 1: the problem of uncertainties of technological innovation and change. The literature review for this thesis is divided into two sections: in the first section I discuss aspects of technological innovation and change in society: how innovation is projected, shaped, and addressed. The second section draws further attention to ICTs in particular, where the key concepts and frameworks to address complex processes of the design, development, and use of ICTs were introduced, discussed, and to some extent, employed for the study of WiBro.

Chapter 3 presents the overall design of this research along with the methodology adopted to conduct this study. In this chapter, I explicitly discuss how the choices were made; choices ranging from those that delimited the boundary of this research to various methodological choices. I introduce the general framework for this

research, the case sites studied, key methods used during the field work, and the methods for data analysis. I also offer some reflections on the research.

Chapter 4 is the first of three empirical chapters, consisting mainly of the empirical analysis based on the case study of WiBro. This chapter discusses the initial stages of the technology design and development, which involved varying interests in dispersed processes of innovation that were gradually linked to the development of WiBro. It deals with events and activities of players involved from approximately 2001 to 2005, beginning with the period that includes initial activities advanced towards the design and development of WiBro until the year commercial WiBro-system products were fully developed to be deployed in the market. This chapter focuses on the dynamic interactions among diverse players who coordinated and built alignments.

Chapter 5 is the second empirical chapter, which links the stages of initial design and development of an emerging technology to the process of appropriation. In this chapter, the analytic focus shifts to the process of commercial uptake of emerging technological products and the services. Therefore, the process of *appropriation* highlights the divergence and discrepancies that arise during the process of commercial uptake of an emerging technology and standard. In contrast to the process of building alignments, discussed in the previous chapter, this chapter focuses on dynamics that made the alignments rather incomplete: incomplete in varying interests carrying differing priorities, aims, and strategies while pursuing the shared goal and vision. This chapter also presents other dynamics that brought the actual uptake of the generic capabilities of the technology away from the initial visions and anticipations. Although focused on the gap that arose through the complex processes of innovation and uptake of the technology, it does not attempt to mediate the gap, but rather to explicate the gap.

Chapter 6 is the last empirical chapter, added as the research came to highlight not only the complexities but also the changing contingencies over time. The chapter mainly addresses the shaping of choices that effectively delimited the boundaries of application areas of WiBro, explicated through the interactions among the innovation

players whose interactions were also greatly influenced by and also shaped the evolving mobile technologies and mobile services. Yet, the diverging outcomes also produced controversies through which particular directions for future innovation were shaped, thereby representing the dynamics of changing contingencies which were, nonetheless, shaped by, and themselves shaped the human choices of technology design, development, and use.

Chapter 7 integrates the findings from the empirical research to answer the research questions. It introduces the concept of distributed governance of innovation, as a mode of governance for technological innovation and change, based on the empirical findings from this research.

Chapter 8 is the concluding chapter, including my final remarks on the findings and how they contribute to knowledge. The chapter addresses some reflections on the research as well as the directions for future research. Key implications for policy are drawn out.

Chapter 2. The social shaping of technological innovation and change

2.1 Introduction

Technological innovations proliferate while there is little assurance about the outcomes beforehand. Technological innovation often appears in the form of emerging technologies that entail opportunities and uncertainties about their future uptake. In many cases, however, the projections about the anticipated future of a technology can become a powerful driving force, setting the direction for innovation. Yet, the ways in which these projections are formed and how they are incorporated into technology development is extremely complex, arising from interplays of diverse arrays of actors and factors (Russell and Williams, 2002; Williams et al., 2005). Contingencies of use and other contexts linked to technologies bring further uncertainties about what may have been projected as the future.

In some fields (and especially the physical information infrastructural technologies being explored here), innovations entail large-scale resources and networks of players at national and the global levels geared towards certain directions of technological change. Such innovations, supported with large-scale investments as well as collective activities and goals, still face challenges with regard to wide and timely uptake by the market and society (Russell and Williams, 2002). Some are confronted with risk issues whereas others face discrepancies between what had been the projected future (Lyall and Tait, 2005) and the reality they come to face. Furthermore, misalignment between projections at the design stage and the reality in use is often recognised only in hindsight (Stewart and Williams, 2005). Still others may face obstacles from inflexible and tardy processes of necessary changes in the social system (Johnson, 1992).

This chapter discusses the problem of uncertainties of technological innovation and change on the one hand, and the complex dynamics on the other. These are perhaps two sides of the same coin. The problem of uncertainties are often addressed by recognising a gap between initial visions and actual outcomes. In this case, this gap had been projected as a problem of diffusion – e.g. diffusion lag. Thus, it begins by reviewing diffusion studies but moves quickly towards a broader discussion of the

co-shaping of technology and society reflecting the need to look into the process of the technology being shaped. However, further review of literatures on managing uncertainties of socio-technical change raises the need for reflexivity in examining the problem of uncertainties – to take into account how the intentions, visions and aims have been co-shaped through the process of technological innovation.

The second section focuses upon sociotechnical dynamics – and thus, complexities - in the process of innovation, and uptake of information and communication technologies (ICTs) in particular. In the field of ICTs, standardisation has become key to complex and dynamic interactions among the various actors involved in the process of technological development. The social-learning framework links this relatively supply-side-focused dynamic with that of the user side. The social-learning framework highlights contingencies in the process of user appropriation of new offerings that are not fixed at the outset, but go through multiple iterative cycles of design, development, implementation, and use. Learning becomes central to this cyclical feedback relationship, explicating the gap between the initial visions and actual use. Concepts such as intermediaries, the multilevel game, and development arena are introduced and applied to map and analyse the complex interactions.

2.2 Dealing with uncertainties: From diffusion to social shaping of technological innovation

The starting point of this research was a concern with how technological innovation gets diffused, and how and to what extent the process of wide adoption and diffusion may be directed and managed. This section first evokes discussion of the notion of diffusion of innovation where diffusion has been characterised through patterns of adoption over time. Although varying factors have been identified that influence the rate and mode of adoption, diffusion studies tend to treat technology as a static object, thereby limiting the scope of enquiry during the diffusion process. Here we turn to the social shaping of technology perspective which broadens the scope for analysing complex interactions involved in the process leading to technological innovation and diffusion. Finally, the section critically reviews current approaches and attempts to explicate and tackle uncertain and contingent processes for technological innovation and diffusion.

2.2.1. Patterns, modes, and rates of innovation diffusion

Many innovations are accompanied by diverse ways of anticipating the future uptake and use of innovations. Diffusion studies have had much influence in estimating and predicting the future modes and rates of diffusion of innovations, and therefore, in assessing them. Diffusion processes have been studied from a number of perspectives rooted in varying fields such as history, sociology, and economics. Primary concerns in the studies of diffusion of innovations related to questions about the factors that influence diffusion, and why diffusion processes, including modes and the rates of adoption, vary. Scholars have sought to explain the nature of introduction and diffusion of innovations in the market and society. In particular, economists have suggested various models and concepts to explain the modes and rates of adoption of innovative technologies, including the growth model of new products (Bass, 1969) and concepts of "network externalities" and "lock-in" (Arthur, 1989; Bass, 1969; Katz and Shapiro, 1986; Menanteau and Lefebvre, 2000). These concepts have explained how innovative technologies, especially newly introduced consumer durables, are adopted, in terms of the rates and modes of accumulation in the number of adopters, as well as external environment consisting of competing technologies.

Roger's study of diffusion (Rogers, 1962, 1995) has also been influential and has provided a widely used framework for studying the diffusion of innovation. Rogers considered the process in which people transferred and shared knowledge and information, as well as how certain forms of persuasion took place that led to adoption or rejection of innovation. Defining diffusion as "the process by which an innovation is *communicated* through certain *channels* over *time* among the members of a *social system*," (Rogers, 1995) Rogers assessed the process as two-way communication about new ideas that may go through several cycles. This process is represented by the S-curve shape, which shows that technologies launch with a small number of earlier adopters and gradually increase adoption over time; the speed is represented through the steepness of the curve. Rogers identified four elements— presenting innovation, communication channels, time, and social system—as key to

diffusion, and investigated how communications between individuals whose response to new ideas (innovation) differ and affect the rate of diffusion.

In particular, Rogers (1995) defined five characteristics of innovation diffusion, seen to influence individuals' decisions to adopt or reject an innovation, thereby affecting the rate of adoption: relative advantage, compatibility with existing values and practices, simplicity and ease of use, trialability, and observable results. The rate of adoption is influenced by the degree to which an innovation is perceived to be better and bring relative advantage to users compared to existing use. The compatibility of the innovation to existing norms, values, and practices of potential adopters would also influence driving, delaying, or rejecting the adoption of innovation. Innovations with simplicity and ease of use diffuse more rapidly than those that require developing additional skills and knowledge. Trialability brings greater certainty to the individual in making decisions for use. Uncertainty may also decrease as individuals observe the results of the innovation, and individuals are then more likely to adopt the innovation.

Diffusion studies, in turn, suggest certain criteria on which to predict, measure, and assess the outcomes of diffusion. Following the models and patterns of adoption, one seeks to find the determinants that lead to 'successful diffusion' or causes for a 'diffusion lag'. However, limits and challenges in assuring timely and wide diffusion of innovative technologies still exist. In particular, technological innovations are increasingly integrated into complex systems of a wide range of interoperating technologies, and thereby involve various social actors, institutional organisations, and systems. The adoption of complex and often-networked technologies such as ICTs, often require continuous learning to align organisational structures, processes, and the technologies on varying time scales (Lyytinen and Damsgaard, 2001). Technologies are therefore intricately related to such diverse factors that together shape the technologies to particular uses.

In diffusion studies, 'social' factors are considered to influence aggregate levels of adoption. How factors come to influence the *content of technologies* (Williams and Edge, 1996), however, is seldom questioned and explained. Rogers (1995) did

consider 're-invention' as an important process involved in the diffusion of innovation, but in the limited sense of recognising the process as one of the key characteristics that enhance the rate of adoption of a relatively static object. Re-invention becomes meaningful only through wider diffusion of the particular innovation in focus. Consequently, the diffusion process is discussed as a social process or phenomenon, less in relation to the technological-innovation process, often drawing on a static view of technology (Sorensen, 1996).

Within the current dynamics of technological innovation, varying efforts are made to measure and predict the patterns, modes, and rates of diffusion of particular technological innovations. Strong visions that often drive industry- or national-scale innovation are often predicated on efforts to estimate the future. These estimates and visions then become the criteria upon which the outcomes of technological innovation are judged and assessed.

As it was the starting point of this research, this section has briefly discussed the usefulness and the limits of diffusion studies in explicating the factors that influence the diffusion of technological innovation. These diffusion studies have contributed generalized models for explicating the societal process involving wide adoption or lack of adoption of a certain technological product. However in these accounts the artefact is generally regarded as being constituted by a more or less stabilised set of technical components and features. However, the diffusion studies often leave unexplored the question of how the technical properties – or the content of technologies - are further shaped by, or shape the societal process leading to particular mode of adoption and use of the technologies.

The following section brings the initial inquiry on the problem of diffusion towards an interrogation upon the process of shaping technology through its lifecycle of being designed, developed and used.

2.2.2. The co-evolution of technology and society

Scholars in STS and especially social shaping of technology (SST) have observed the negotiation process upon making 'choices' that involve interactions among various social actors and factors in shaping the content of technology (MacKenzie

and Wajcman, 1985; Williams and Edge, 1996). The SST perspective provides a helpful analytical framework on which the negotiation processes can be observed along with the process of making choices in technological and social options. The SST perspective arose from recognition that technological change does not follow some inner logic of technology into a clear, predetermined, and foreseeable path. The scrutiny of technological change and its relationship with society by scholars from the field of STS have widened the analytical stance to embrace the technological, social, cultural, economic, and political factors and their interactions. The scope of this research thus embraces the broad spectrum of innovation and diffusion processes where the mobilization of technological options and social choices and their reciprocal impacts may be observed.

Studying the innovation and diffusion of technologies from the social-shaping perspective has been the prevalent and major interest and occupation for scholars in STS. Earlier works based on the social-constructivist perspective focused on the reshaping and redesigning of artefacts by various social groups or *relevant social groups* or *actors* involved in technological development and diffusion (Bijker, 1992; Pinch and Bijker, 1984). More recent studies in STS, and in SST in particular, undertaken on a wider range of technological areas, suggest more sophisticated approaches that consider the diversities and complexities of interrelated actors and factors in sociotechnical constructs or systems, as they focus on the processes of technological development and use that bring about a coevolution of technology and society.

By integrating diverse research areas of technological innovation including evolutionary economics, politics, history, cultural studies, and many others, SST studies have contributed to building insights about the dynamism in interactions between technologies and a broad range of mechanisms in society. The detailed case studies based on an SST perspective and broader scope of STS have shown how alignments of diverse interests bring about technological change, stabilisation, and entrenchment in sociotechnical systems (Law and Callon, 1992), and go through or face restructuring, reconfiguration, or a transitional shift (Geels, 2002a). Furthermore, innovation has taken place continuously as technologies are brought into the

implementation and appropriation process, finding the innovation processes to be iterative rather than linear (Fleck, 1999; Williams et al., 2005). The studies that especially considered the appropriation and domestication of innovative technologies have scrutinised how differing concepts and meanings are given to technologies by customers and users, and how they, in turn, affect and shape technologies, just as the use and users are configured to particular modes of use according to the *inscription* (Akrich, 1992) of developers to a certain degree.

Although there has been increasing recognition about complexities in the technological-innovation process and the resultant contingencies in the nature of the coproduction of technologies and society, recent studies of SST have also observed efforts in the policy domain to counteract the complexities and contingencies by other means of *shaping* the technology and society. On the one hand, policy structures and directions have become much geared towards inclusiveness and participatory style (Lyall and Tait, 2005). On the other hand, such a move could be seen to head towards mapping and assessing future outcomes of certain technological development at early stages of innovation (Williams, 2006). Such tendencies raise additional questions in relation to linking the insights about the relationship between technology and society with possible actions to take to manage favourable conditions for the coevolution of technology and society.

Much of the technological innovation taking place in our present society tends to be driven by the combination of aims and fears about the outcomes of the interactions between technological innovation and society. Technologies are framed, planned, and assessed at a very early stage of development in its use, modes of adoption, as well as the outcomes of accumulative appropriation and social embedding of the technologies, well in advance of their actual implementation and appropriation, let alone development. Such modes of technological choice take place in varying scales: from a relatively small scale at individual firms through larger industrial partnerships, and even larger scales of national initiatives or international coordination.

However, such a trend does seem to have turned away from the traditional linear model based on a simplistic assumption of a seamless flow from research and

development to production and then to diffusion through market and society. The technology policy of the European Union, for example, has shown a new orientation towards recognition of the complexities and uncertainties in the technological-innovation process, the difficulties of control, as well as the need for integration and flexibility in science and technology policy (Russell and Williams, 2002). The shift also has or is taking place in many other parts of the world in developed and developing countries, albeit to different degrees and with different approaches.

Yet, intentions, goals, and projections are directing much of the present technological innovation and comprise the essential elements of the drivers of the present society. To a certain extent, the resilient linearity of the basic frame of the projection and drive for technological innovation may represent the characteristic of a social process. Although technological change may endeavour to be more inclusive towards broader views and wider accounts, it will still be placed within fluctuating goals, projections, and directions. Therefore, it seems critical to view such a process not only as an attempt to *intervene* in the technological innovation process but is itself a social process that needs to be examined vis à vis the dynamics of the technological innovation and diffusion processes: how the evolving goals, intentions, visions, and projections shape and are shaped by technological capabilities, social appropriation of innovative technologies, and modes of uptake and use by the consumers and by the public, which together comprise the complex map of the sociotechnical environment.

2.2.3. Managing uncertainties of technological change

In recent decades, uncertainties have become one of the major concerns in technological change. Several sources of uncertainty have been recognised in the development of technologies and innovations in many areas of science and technology. For example, increasing concerns about risks and undesirable outcomes of technological innovation gave rise to challenging tasks for regulators, policy makers, and developers. Also, industry and governments have been faced with certain challenges to link emerging technologies to market and potential users. The linear model of innovation (incorporating a view of innovation as driven by advances in scientific knowledge and industrial research) that has dominated

technology policy for several decades has largely given way to the recognition of the need for more sophisticated approaches, such as those that encompass the whole lifecycle of a technology, from research and development to use (Russell and Williams, 2002).

However, the limitations of the linear model have not been fully overcome whereas efforts have been made to bring about more integrated approaches towards considering complex interactions among diverse actors and factors that directly or indirectly influence and are influenced by the technological innovation. The inherent complexities that arise from the integrated model pose additional challenges to possible interventions to guide technological innovation with desirable and desired outcomes. It seems there is no definitive answer or generally applicable method to tackle such challenges, whereas this does not negate the effectiveness of the efforts to manage uncertainties in the societal uptake or societal embedding of technological innovation (Deuten et al., 1997).

Management approaches and the relevant conceptual tools based on the understanding of the complex relationship between technology and society have been introduced by the scholars in the field of technology and innovation studies including the constructive technology assessment (CTA), technology transition (TT) with a multilevel perspective, and strategic niche management (SNM). CTA has sought to improve the ways of addressing uncertainties and contingencies of technological innovation through ongoing anticipation and broadening the design, development, and implementation stages to include iterative learning processes among heterogeneous actors (Rip et al., 1995; Rip and Schot, 2002; Schot and Ripp, 1997). CTA has been aimed at managing the process of technological change, based on an assumption that the internal process of technological development can be steered, to a certain extent (Schot, 1992, 37p). Attempts to steer such complex processes require societal learning where feedback and reflexivity become critical. However, additional challenges were recognised to facilitate such learning processes, especially where the feedback from a broadened agenda was seen as less effective in the process of technology design (Schot and Rip, 1997).

SNM, an offspring of this approach, offers a view of creating and constructing technological niches to facilitate the processes to allow sustainable innovation by bridging the new technologies and their market introduction (Schot and Geels, 2008). Technological niches are the sources or spaces for radical novelties, developed while being protected from the competition in existing selected environments. Technological niches are different from those considered market niches, as the technology design and user demands have not yet been stabilised (Schot and Geels, 2007). Yet, they are constructed often involving policy makers, as well as users. SNM thus addresses management challenges in matching a radical innovation to the social environment where the novel technologies are to be embedded, as well as the long-term sustainability of innovations.

These conceptual analyses of technological change have been further elaborated through a multilevel perspective (MLP) built on the observation of the process, framed as TT. The MLP provides a conceptual framework based on horizontal and vertical interactions among diverse players, regimes, and the larger environment. The multi-level framework consists of the micro level of 'niches', the meso-level of 'sociotechnical regimes,' and the macro-level of 'sociotechnical landscape' (Geels, 2002a). It stresses the linking of ongoing processes at each level (Schot and Geels, 2008). Niches are radical novelties that emerge often in response to the problems, rules, and capabilities of existing regimes and landscapes. They emerge in a protected space while they still have low technical performance, which separates them from the competitions from market selection in the existing regime. The existing regime represents the meso-level of sociotechnical regimes where technological developments follow certain degrees of stabilisation and trajectories, generating incremental innovation. The macro-level of sociotechnical landscape consists of structural and material context in which the establishment and arrangements render it difficult to change, often requiring longer-term changing processes than the regimes (Geels, 2002a).

The relationships between the levels are conceptualised as follows: Niches are produced on the basis of the existing sociotechnical regimes while also being influenced by existing landscape. Although ongoing practices and processes

characterise each level, niches may find opportunities to move from uncertain radical novelties towards stabilisation at the regime level as tensions emerge in the sociotechnical regime or shifts occur at the landscape level that also put pressure on the regime level. Then the regimes and landscape that had been configured based on existing technologies go through reconfiguration, albeit at different degrees of difficulty, that may eventually bring about successful introduction of new technologies to society, culminating in TT (Geels, 2002a; Kemp et al., 1998).

The process of TT has thus been illustrated, and over the years the MLP has gained wide recognition as a useful theory to explain and guide the transition process. A number of case studies have been built on the model suggested by MLP, whereas many have been aimed at informing policy-level practices related to the governance of sociotechnical change (Belz, 2004; Correlje and Verbong, 2004; Geels, 2002b). However, critics assess its key conceptualisation of levels and their interactions, as well as its practical applicability to policy agendas for governing sociotechnical change or transitions. Whilst the regime shift is the key focus of studies of TT, Berkhout and others (2004b) argued that MLP, by drawing on past histories of sociotechnical transformations, tend to bring a risk of treating the transition process as a *unilinear* process. The niche-driven interactions, particularly built on historical narratives of regime change, tend to assume a degree of inevitability about the process and the outcome.

Smith and others (Smith et al., 2005; Smith et al., 2010) have argued for better understanding of sociotechnical transitions as changes mediated by actors and networks of actors, through their interests, expectations, and resources. MLP has also been complemented with further acknowledgement on the roles of the agent and actors in the causal mechanisms working through the levels (Geels, 2010). Sociotechnical change poses to be a 'global model' of overall paths and patterns to be complemented by a 'local model' of actions (Geels and Schot, 2007). Still, the task of bringing the main narratives of level interactions to the level of agencies and actors remains, if it were to offer 'navigational support for actors' (Jørgensen 2012, 997). Mapping the mediating actions and interactions of various actors and agencies rather than the levels may, however, be better placed to elicit suggestions to navigate

towards future transitions, thereby enhancing the 'prescriptive usefulness' (Jørgensen, 2012, 1001p) of the approach.

So far, such depiction of the world has been applied to seek explanations about technological transformation that also involves transformation of other elements of society including organisations, regulations, infrastructures, and cultures. TT is an analytical framework based on retrospective observations on sociotechnical change, aiming to provide a tool that can serve as a forward-looking glass as much as a retrospective one, creating a challenge regarding the extent of extrapolation from the past experience in the act of anticipation. Also, anticipation is twofold in considering the present web of heterogeneous actors and factors, and possible outcomes of their interactions, whereas the present niches are themselves being formed on the basis of the actors' expectations. However, the twofold act of anticipation about niches and outcomes is itself a sociotechnical process which not only influences actor networks, technological changes, and shifts in regimes and landscapes, but is also influenced by them. Therefore, reflexivity seems to be centrally placed, along with the diversity and complexity to be considered in attempting to tackle the uncertainties and contingencies of sociotechnical changes and the coevolution of technology and society.

2.2.4. Summary

This section reviewed scholars' work in various fields that addressed issues related to technological innovation and change: the patterns of technology diffusion, the process of shaping technology, and the approaches that have aimed to direct and manage technological innovation and change. Diffusion theories have especially resorted to modeling patterns drawn from aggregate levels of adoption over time, and applied to varying degrees of anticipating future diffusion of innovations and assessing the outcomes. Certain factors influenced the time of adoption by affecting the individual as well as interpersonal decision-making criteria. Yet, the decision making was viewed as a unilinear process, unconcerned with changes in the shape or content of the technology being adopted.

The SST perspective contributed insights and recognition of the need to broaden the spectrum for viewing the relationship between technology and society. Complexities and unpredictability in the process of technological innovation and diffusion were stressed, while cautioning against simplistic and hasty attempts at controlling the directions of technological innovation and change.

Building on these insights, as well as insights from evolutionary economics, scholars have introduced and suggested analytical frameworks and tools for more practical approaches to addressing the uncertainties and contingencies in innovation and diffusion of emerging technologies. By offering conceptual tools to examine vertical and horizontal interactions among diverse actors and factors in broadened arena of sociotechnical changes, for example, the MLP has been suggested to guide understanding and assumptions about possible interactions between emerging technologies and their embedding environment. Yet, such guidance inevitably carries some simplification of the complex world, which requires further scrutiny into the complexities that may have been left undescribed.

2.3 Sociotechnical dynamics of innovation and uptake of ICTs

This section focuses on particularities of ICTs in relation to technological innovation and uptake. ICTs have been developed and widely adopted throughout society during recent decades. Furthermore, technological innovation and diffusion of ICTs are increasingly linked to large-scale global networks of infrastructures, complementing technologies and services through continuous development and advancement. Due to network externalities and compatibilities among these technologies and services, technological innovation in ICTs, and in particular mobile-communication technologies, are often pursued in collective and proactive mode (Shin, 2006a, b). However, despite the collective and often coordinated innovative activities, uncertainties arise with regard to appropriation and uptake of the emerging technologies in society.

Complexities, uncertainties, and dynamics in the development and diffusion of ICTs have been recognised and evinced, especially through the studies of standardisation whereby alignments of different interests, conflicts, and active processes of

collaboration and coordination have been highlighted (Graham et al., 1995; Kano, 2000; Oshri and Weeber, 2006; Williams et al., 2004). These studies offer helpful insights into additional challenges in the future uptake of those often large-scale networked technologies in which boundary and scale are not limited to a single organisation or an industrial sector.

Dynamics of user appropriation of ICTs are examined through the social-learning framework, which complements and brings the scope beyond supply-side interactions. In particular, the social-learning perspective in technological innovation provides a lens through which to focus on the detailed processes of design and development, as well as the take up of innovative technologies in society (Rip et al., 1995; Williams, 2000; Williams et al., 2005). User appropriation of ICT particularly highlights complex learning processes and knowledge flows among heterogeneous players, representation of users and uses, and the processes of appropriation by actual users (Williams, 2000; Williams et al., 2005)

These processes, involving complex interactions and relations, were mapped for analysis based on the concepts of intermediaries, the multilevel game (Williams, 2000; Williams et al., 2005), and the development arena (Jorgensen and Sorensen, 1999). The concept of intermediaries has been employed to observe the roles and activities that have been engaged to bridge the varying levels of supply and use dynamics. The concept of the multilevel game maps the perceptions of innovation actors as their roles and goals diverge from those that had initially been taken. The concept of a development arena brings these dynamic interactions of intermediation, alignments, competition, and divergence into a cognitive space, as they are held together by certain linkages.

2.3.1. Standardisation in ICTs and the evolution of mobile standards

The evolution of mobile technologies and mobile services has involved dynamic interactions among the diverse arrays of innovation players including the manufacturers of technologies, government, public research and development institutes, service providers, and users in their particular institutional structures, social systems, cultures, and political environments. In recent decades,

standardisation has become one of the most prominent sites for interactions, whereas the development of technical standards and standards-setting activities have aimed at achieving compatibility and wide interoperability among differing technologies and systems that are increasingly implemented in large-scales, beyond the boundaries of the nation states. Furthermore, the evolution of mobile-communication technologies have largely resorted to proactive standards-setting activities where alignment through cooperation and competition actively take place due to high ambiguity in technological development. Various reasons for such proactive and collective moves include rapid changes in knowledge and interests, rapid innovation of new products and services, increasing fragmentation, and the costs of innovation exceeding the proprietary benefits that may ensue (Oshri and Weeber, 2006; Van De Ven, 2005).

Anticipation has therefore increasingly played a major role in standards setting processes of mobile-communication technologies, as the standards are often pursued prior to the existence of the markets for the standardised products or services (Lee and Oh, 2008). Standards in general can be understood as 'a set of technical specifications that can be adhered to by a producer, either tacitly, or in accordance with some formal agreement, or in conformity with explicit regulatory authority' (David and Steinmueller, 1994, p218). In this regard, anticipatory standards carry the characteristics of guiding future compatibility or interoperability related to products, systems, or service platforms (Lyytinen and King, 2006). Mobile-communication standards generally fall into a category of 'compatibility standards', defined as those that 'assure the user that a component or sub-system can successfully be incorporated, and be "inter-operable" with other constituents of a larger system of closely specified inputs and outputs' (David and Steinmueller, 1994, p218).

However, seeking interoperability, especially in an anticipatory mode, incorporates further challenges, as the interoperability between heterogeneous sets of components such as terminals, network devices, platforms, and software systems often extends beyond the domain of technical compatibility: it further requires future compatibility with broader systems in society that represent complex sociotechnical systems (Williams et al., 2004). Interoperability must align with existing values, past experiences, and needs of potential adopters, as it moves towards wider diffusion

(Rogers, 1995). Therefore, the boundaries of interoperability are often extended to consist of heterogeneous actors and factors that interact with the technology.

There are a wide range of actors and factors whose interactions shape and are shaped by standardisation, whereas the coordination of these interactions poses additional challenges in bringing about workable standards. Scholars have attempted to examine and investigate the interactions among various actors in the process of innovation and evolution of information and communications technologies and standards. Studies based on the actor-network theory (ANT), in particular, have shown how actors pursue alignment of interests, thereby bringing standards to *closure* or *irreversibility* (Fomin, 1999; Hanseth, 1996; Yoo et al., 2005). Yoo et al. (2005) for example, examined how configuration of actor networks were mediated and coordinated through standards and led to successful innovation and diffusion of a broadband mobile infrastructure and services. In their analyses of the innovation and diffusion process, standards played a pivotal role in aligning and coordinating different and conflicting interests, thereby enrolling key actors to build necessary actor networks. Standardisation here is viewed as a process where agreements regarding the necessary specifications of technology are achieved among a set of actors who go through the process of the *translation* in which persuasion and enrollment bring other actors into a network. Successful enrollment in the process would then enable certain technology to be selected, thereby achieving *closure*. The success or failure of a standard, they argued, depends on the configuration of actor networks, through which the associated networks reach *closure* and thus become irreversible.

ANT-based analyses generally leads to observing the unification of networks whereby closure to certain technologies and configurations of actors are reached. The core concepts such as *translation*, *alignment*, and *irreversibility* describe how heterogeneous actors, when successfully performed, finally come to consensus on certain aspects of technologies and modes of interactions, which brings a rather partial and monotonous view of the world as a whole. Their focus remains, furthermore, on the coordination and cooperation of actors, failing to capture the

aspects of competition between different actor networks (Jorgensen and Sorensen, 1999; Williams et al., 2004).

Indeed, the global evolution of mobile-communication technologies and standards in the recent decades has highlighted varying degrees of alignments, competitions, and conflicts during the process of the development and implementation of the standards. First-generation mobile-communication technologies were introduced in the early 1980s while the systems installed across the globe were based on seven mutually incompatible national standards (Bohlin et al., 2010). A large number of European countries were then aligned to develop and implement the second generation of mobile-communication standard; they formed a global system for mobile communication around the European Technology Standards Institute. Yet, strong alignment among the European equipment and service providers caused a measure of barriers for firms outside Europe to enter the community (Funk and Methe, 2001), which in part resulted in the formation of alignment around a separate standard of code division multiple access (Lee et al., 2009). The global mobile-phone market was fragmented by having five different standards.

The evolution to the third-generation standard was further accompanied by the role played by the International Telecommunications Union for the harmonisation of global standards (Ames and Gabor, 2000). The International Telecommunications Union initiated the international mobile telecommunications IMT-2000 project to set the framework for the third generation (3G, (Chen and Guizani, 2006; Kano, 2000). The collaboration among industry and standard-setting organisations led to the coordination of two partnership projects, one based on GSM and the other on code division multiple access systems. The standardisation thus moved away from hierarchical structures of national level coordination towards global, industry coordinated consortia (e.g., 3G partnership project, 3GPP2; (Tilson and Lyytinen, 2006).

The outcome of such collaborative efforts however varied by region and nation state. The roll out of 3G in Japan was regarded as a success accompanied by its particular market structure (Lindmark et al., 2004). However, although European nations had

collectively chosen the evolution path towards 3G, many had delayed its commercial implementation and failed to achieve the anticipated rate of adoption in an expected time (Ansari and Garud, 2009). They were also faced with varying issues that conflicted with what had been anticipated initially: users did not enact the vision of 3G, which was driven mainly by suppliers of technology and services; and they lacked compelling applications and content (Ansari and Garud, 2009).

Standardization as a process represents strategic alignments and articulation of heterogeneous interests and expectations (Graham et al., 1995; Williams et al., 2004). Standards setting generally leads to collective choices on certain technological frames through agreements, alignments on solutions of conflicts, and recurrent problems. This may be viewed as 'striking a balance between the requirements of users, the technological possibilities and associated costs of producers, and constraints imposed by government for the benefit of society in general' (Tassey, 2000, p588). However, such a collective move towards seemingly balancing heterogeneous interests and issues of wider society does not always lead to smooth introduction and implementation, leading to wide diffusion of technologies. Although greater complexities of technologies often bring analysts' focus onto the supply side networks of research and development, manufacturers, and service providers, there is still a crucial conceptual gap that needs to be linked between the dynamics on the supply side and the user side in the development and appropriation of technologies.

2.3.2. Users, appropriation, and social learning in technological innovation

This section brings the discussion of use and users in the process of technological innovation and uptake. Recognition of the role of users expands in the process of design and development of emerging technologies. The notion of user innovation per se emphasises the role of users in the innovation process: the perceptions and real-life experiences of the users were incorporated into the process of actual design and development of new market products and services (von Hippel, 1986, 2005). The sphere of use and users, however, reaches beyond informing future directions of the development and introduction of new technological products and services in market;

it incorporates uncertainties and contingencies in the shaping of technologies and technological pathways. Extending from the perspective of social shaping of technology, the social-learning framework focuses greater attention on the contingencies in the process of use and design by focusing on how the complexly interwoven choices in the cyclical process of design, development, through implementation and use together shape technology and the evolving paths of technological innovation (Rip et al., 1995; Williams, 2000; Williams et al., 2000; Williams et al., 2005).

Projection of users and uses in particular has increasingly become crucial to the present state of technological development. They often serve as an important source to rationalize and promote future directions of technological innovation, often enforced through visions and anticipation of future use (Stewart, 2005; Williams, 2000). Images of users and customers often become a "currency" used to enroll necessary resources for development, as well as to attest or mobilize visions through business-trial environments (Nicoll, 2000). However, although the presumptions of use and users are incorporated into an initial design of the technology, the representation of the intended users and uses does not easily lead to smooth uptake by actual users through the implementation and diffusion stages. Concepts such as 'configuring the user' (Woolgar, 1991) and 'inscribing' (Akrich, 1992) stress how developers and innovators construct and appropriate user representations and their own understanding of the contexts into the designs. However, the suggested solutions, such as achieving the convergence of all the different user representations by developing and incorporating user representations during the design stage (Akrich, 1995), do not offer ideal means to link the gap between representation and actual use or users. Even an attempt to carry out an explicit investigation on future uses and users would, at best, gain partial representation of the prospective use of the technology (Hyysalo, 2006; Stewart and Williams, 2005).

Thus, problems of design are an inherent problem, critical to successful innovation and implementation of new technological products and services, whereas their shortcomings or mismatches become evident only at the stage of actual consumption. The social-learning perspective addresses these challenges while it explicates the

inherent gap between suppliers' offerings and the actual adoption of technologies. It provides a lens through which to focus on detailed processes of design and development, as well as the adoption and use of innovative technologies. It emphasises the 'learning' process that takes place in the course of acquisition and integration of technologies into local use and the user environment. The term 'social learning' does not indicate a 'narrowly cognitive process' but is instead regarded as a 'process of negotiation, subject to conflicts of interest amongst players with rather different capabilities, commitments, cultures and contexts' (Williams et al., 2005). The value of a social-learning perspective therefore lies in its extension to the scope of observation beyond the stages of design and development, and to enter the process of appropriation and use. The concept of *domestication* is key to social learning, as it seeks to observe how people explore technical capabilities and give meaning to the technology whereas the technologies are integrated into local social settings (Silverstone and Haddon, 1996). Brosveet and Sørensen (2000) thus described the process of social learning as the 'process of using, producing, and making sense of the new technology, emphasizing spatial as well as temporal aspects' (Brosveet and Sorensen, 2000, 263p).

Although the gap between the design and use seems pertinent to the reality of pursuing technological innovation, which precedes the existence of evident demand or market, the gap needs to be viewed not with a linear conception of the process of design followed by use, but in a rather more cyclical relationship between user representation, design, and appropriation (Williams et al., 2005). The gap comes to represent a space where developers and users, as well as other relevant players, interact directly or indirectly with each other, and form a cyclical feedback relationship. This conforms to the idea that technological innovation is not just a matter of production but includes consumption and use as an essential part of the innovation process:

> Technological innovation is not just a matter of production. Consumption and use are equally essential components of the innovation process. Technological innovation is also not just a matter of engineering. Both new and old technologies are social products: they are symbolic and aesthetic as

well as material and functional. Production and consumption are not related
to each other in a singular or linear fashion, but are the product of a complex
pattern of activities in which producers and consumer-users, as well as those
who intervene in and facilitate the process of consumption, take part.

<div align="right">(Silverstone and Haddon, 1996, p44)</div>

Through the studies of diffusion and use, practitioners increasingly recognise that
diffusion and use are intrinsic parts of the innovation process (Fleck, 1988, 1999;
Haddon, 2005; Hall, 2005; Nicoll, 2000; Silverstone and Haddon, 1996; Williams et
al., 2005). Observations have been made in various settings and sites ranging from in
industrial organisations to mass-market environments, where evidence of innovation
during implementation or appropriation of new technologies could be traced.
However, the extent to which innovation may occur during the diffusion process
may vary depending on certain factors that affect the appropriation process such as
strength of supplier-user links, locations of consumption, and the possible scale of
adoption (Williams et al., 2005). Innovation during diffusion is particularly related to
the modes and intensity with which users engage themselves with innovative
technologies: how they identify objects; how, where, and why they decide to
appropriate the technologies; and so forth.

Successful introduction and uptake of new technologies therefore means the
technologies or artefacts become 'situated practically, and symbolically, while the
social system develops routines and institutions to support and regulate it' while the
users 'construct practice as well as meanings around the artefact' (Brosveet and
Sørensen 2000). Brosveet and Sørensen (2000) called this process 'domestication'
through which the artefact turns from an alien to a recognisable element. Such a
notion of successful embedding of technology in society brings further attention to
reflexivity; especially of the actors involved whose particular experiences lead to
'responding creatively to novel and changing circumstances' (Williams et al., 2005,
91p).

The social-learning framework thus leads to encompassing the process of
sociotechnical change, where choices and reflexivity reciprocally shape technology

and society. The process of diffusion is merged with the process of design and development in the analytical scope that embraces the cyclical processes of design, implementation, and use. The analytical sphere thus brings attention not only to the initiation of often a grand visionary project and its outcome, but also on the mediating visions, choices, and actions that link heterogeneous actors and factors. The outcome is then not to be heedlessly assessed against the initial visions and conceptions of the technology, but to consider various interactions involving designers, suppliers, regulators, intermediaries, and end-users. Although supply-side and user-side dynamics have been the two main pinnacles of innovation and technology studies, the social-learning framework brings greater attention to intermediate-level interactions, where varying translations of technologies, shifting choices, and interests of appropriation dynamically shape the design and use of the artefact.

2.3.3. Mapping the dynamics of complex interactions: Intermediaries and the multilevel game in a development arena

Intermediate-level interactions or the term intermediation is used in this thesis to mainly denote a range of activities concerned with bridging the domains of development and use (Williams et al., 2005). Particularly in relation to complex technologies such as ICTs, this process is vital in linking not only consumer products and services to use, but also linking many layers of complementary technologies, systems, infrastructures, and applications that together constitute the products and services. Thus, the process of intermediation is not always straightforward in the sense that the sites for linking development and use can be numerous and distributed across varying levels of the appropriation process. The players involved in such an intermediation process are denoted as 'intermediaries' whereas the intermediaries have been observed to emerge rather than 'follow formal and predetermined structures and roles' in the course of an ICT experiment (Williams et al., 2005, 80p).

Intermediaries in innovation processes have broadly been viewed as organizations or individuals having various roles in supporting and facilitating innovation and diffusion by mediating activities such as dissemination of information, knowledge, and technology transfer, and provision of applications or solutions to market needs

(Howells, 2006). In the framework of social learning in technological innovation, intermediaries are identified as individuals or institutions that learn and facilitate learning by others, transferring and translating relevant knowledge and information (Stewart and Hyysalo, 2008; Williams et al., 2005):

> Intermediaries are continuously forced to learn about, filter, translate and reflect on information, products and practices of other actors to remain relevant and thus in existence. An important part of this learning is about how to relate and manipulate as well as how to dominate and control other actors around them.
>
> (Stewart and Hyysalo, 2008, p311)

Stewart and Hyysalo (2008) explicated the role of intermediaries in relation to social learning by identifying roles in three distinct categories: facilitating, configuring, and brokering. Facilitating includes activities of setting spaces to provide opportunities to fulfil various needs. The activities may involve education and training, gathering and distributing resources (e.g., physical devices or economic funds), influencing regulation, and creating rules for managing and reducing uncertainties. Configuring involves processes to facilitate appropriation of technologies by others through technical and symbolic influences: the activities include adjusting technology for use, as well as creating and configuring contents and rules on the basis of the interpretation and meanings that are given to the technologies by intermediaries, sponsors, suppliers, and users. Brokering includes means for bridging and bringing together suppliers, users, and other necessary actors into the innovation process, often through direct communication, thereby gaining support for the appropriation of innovative products and services. Intermediaries mobilise and mediate between suppliers and users of various layers of technologies (e.g., platforms, components, content, and applications) as well as other actors involved. Intermediaries thus include a wide range of players such as retailers, consultants, certain types of knowledge-intensive business service firms, banks, ICT platform operators, advertising agencies, and so forth (Howells, 2006; Stewart and Hyysalo, 2008; Williams et al., 2005).

The role of intermediaries becomes at once challenging and crucial, especially when the market for the product is nascent; thus, uncertainties about potential uses and users prevail, and the link between the supplier and the user is not yet present or fragile. In such circumstances, intermediate actors need to "create spaces and opportunities for appropriation and generation of *emerging* technical or cultural products by others who might be described as developers and users" (Stewart and Hyysalo, 2008, 296p). Stewart and Hyysalo termed these actors *innovation intermediaries* and identified them as follows:

> Innovation intermediaries can be identified by their engagement in activities in which they gather, develop, control and disseminate knowledge, collect and disseminate financial, technical and institutional resources such as the support of users and sponsors, and attempt to regulate uses, developments, participation and the actions of others in the innovation networks. … These intermediaries can be organisations, or individuals grounded in an institutional, technical and often physical context that facilitates their activities.
>
> (Stewart and Hyysalo, 2008, 297p)

The concept of intermediaries drawn from the framework of social learning in technological innovation includes a wide range of intermediate actors in innovation processes, and provides a rather holistic picture of the intermediaries while offering a space for detailed analyses of the interactions in which they are involved. Innovation intermediaries thus can be those who have the ability (to differing degrees) and interests to coordinate and align different knowledge, expertise, visions, and interests, while they position themselves as both suppliers and users of innovative technologies, as well as bridging the two separate yet connected spheres of development and use.

The concept of intermediary and intermediation can thus be helpful tools to map and analyse complex interactions involved in the process of development and diffusion of emerging technologies, which entail a degree of uncertainty of actual use and uptake. It especially enables us to observe how the meanings of technologies are

created, translated, and transferred between the development and the user sphere by following the intermediate actors who constantly mobilise themselves as facilitators, brokers, or configurers over multiple cycles of innovation and diffusion. Scholars examined a wide range of intermediaries who are placed in a broad sphere of innovation systems (Howells, 2006) or appropriation spaces (Stewart and Hyysalo, 2008; Williams et al., 2005). This thesis applies the concept mainly to explicate the process of making choices upon appropriating mobile-network infrastructures through which the core and component technologies get implemented and used to provide particular applications and contents of mobile services.

Further linked to emerging technologies, the need for a distinctive role of coordination emerges that would effectively create and arrange alliances of diverse arrays of players who take part in the innovation process. The knowledge and information necessary for the development and commercialization of an innovation transcends the boundaries of individual firms, industries, and countries. Thus, an individual firm can seldom manage the whole process on its own, but needs to 'run in packs' with other cooperating and competing firms (Van De Ven, 2005). Aligning expertise and interests that are both intertwined and divergent is a crucial process for successful innovation and diffusion of emerging technologies. Although the collective move may lead to creating institutions that may serve as a coordinator (Van De Ven, 2005) covering the broadest level of multiple players, the collaboration is often driven through active roles of innovation intermediaries (Williams et al., 2005). Coordination—organising or mediating the collaboration of such networks of heterogeneous players—has been one of the key concerns of social-learning process, whereas the intermediaries also play crucial role as coordinators by linking and maintaining the networks.

However, challenges accompany coordination, especially where technologies rapidly advance along multiple layers of interconnecting and complementing technologies and services. Different interests, commitments, scales, and technical capacities and strategies may bring varying degrees of intensities and shifting modes of linkages and engagements to coordinated networks. Furthermore, the diversity of backgrounds for collaborating and building alignments is likely to endorse a

multilevel game among participants: the multilevel game becomes significant, especially where there is a formally stated shared goal for collaboration, and yet more or less covert goals are carried by individual participants (Williams et al., 2005). The covert goals are likely to lead to differing commitments and interests towards a collectively pursued innovation process, from which certain conflicts and tensions may arise.

Meanwhile, bringing about seamless networks and alignments has been a frequently visited theme for bringing new technologies to be embedded in society. Eventual embedding of a new product in an environment, per se, would be built upon the 'web of alignments', whereas the alignments always tend to be partial, carrying various challenges and risks from pursuing particular alignments (Deuten et al., 1997, 140p). Alignments have also been viewed as normative means to bring about 'sociotechnical constituencies', seen as crucial for successful implementation of a new technology (Molina, 1997, 604p). However, building alignments, often requiring coordination, do not always carry multiple interests monolithically aligned, preparing a smooth pathway to the designated destination. The purported goals and visions of alignments and coordination seldom carry identical means and options for heterogeneous players who are nevertheless positioned as more or less committed members of such alignments and coordinations. This thesis therefore applies the concept of alignment where there are strategic linkages among the innovation actors, yet accompanied and further scrutinised by the notion of multilevel game (Williams et al., 2005). The thesis thus considers the inherent sources of conflicts and tensions that arise over the course of building particular forms of alignments. Therefore, deeper scrutiny of the process of innovation and uptake is expected to contribute to furthering understanding of technological pathways and contingencies in the process of technology shaping.

Yet, the innovation process is observed not through a narrowly confined and well-defined problem space of technological development, but through an emergent space that accommodates divergent processes in the making: the notion of a 'development arena' provides an analytical framework to discern such a cognitive space:

a 'development arena' is metaphor for the cognitive space where political, social and technical performances related to a specific technological problem takes place. It is a spatial imagery that brings together heterogeneous elements that seem distant in geographical and conventional cultural space. It resembles the idea of the 'patchwork' of technology stories. … The imagery is spatial, but it is not bound to any specific geographical location. The idea is that the metaphor makes it possible to visualize the many different heterogeneous elements that compete for attention and power in the arena.

(Jorgensen and Sorensen, 1999, 412p)

Dispersed and disparate processes are thus held together by certain linkages that bring about a conceptual development arena. The development arena further proposes to offer a broad perspective that includes the processes of reconfiguration of technologies and the domestication of technology. This arena is, to a degree, related to concepts such as 'sociotechnical ensembles', 'technological regime', and 'actor networks' in that it assumes certain linkages and interactions among heterogeneous sociotechnical elements. However, the 'development arena' has been further characterised by its analytical scope for the processes of 'becoming, shaping and structuring', which stresses the processes in the making (Jorgensen and Sorensen, 1999, 417p). It has also been differentiated from the actor networks and actor worlds of ANT by availing the space with a scope to describe the processes of competition and cooperation (Jorgensen and Sorensen, 1999).

An arena, therefore, can be seen as a cognitive yet emergent space where multiple engagements and interactions are held together by certain linkages that are built on varying relations including coordination, cooperation, and competition. However, such linkages are not to be understood as being set by particular social structures that are predetermined by certain external parameters (Abbott 2004). Linked to Abbott(2004)'s ecological thinking of a space of interactions or a social world, it is "the process of constructing the relations between actors and locations that in fact *constitutes* and *delimits* both the actors and locations" (Abbott 2004, 248). The concept of an arena thus offers a space to observe the processes with a boundary unlimited by or unfixed around a prefigured or prescribed set of interactions. The

emergent characteristic of the space defies prescription, but allows an analytical frame to grow, as it incorporates diverse arrays of interactions over multiple and heterogeneous processes of innovation.

2.3.4. Summary

This section has brought together multiple concepts and frameworks to set the groundwork to analyse complex interactions involved in the development and uptake of complex and often networked, infrastructural ICT technologies. Studies on standards and standardisation demonstrate varying sources of innovation coming together to shape technology and technological pathways: anticipation, vision, knowledge, alignment, as well as coordination and competition operate at different levels of interaction that are recognised through the process of design, development, and implementation of interoperability standards.

Additional insights from the studies of social learning in technological innovation offer the grounds on which to observe contingencies of use. They thus highlight pitfalls of design involving representations of use and users. The inherent gap between design and use is then incorporated in the cyclical learning process that has been emphasised to culminate in the shaping of technologies and technological pathways.

Finally, the complex interactions leading to multiple and cyclical processes of design, development, implementation, and use have been mapped for analysis through the concepts of intermediaries, the multilevel game, and development arenas. Intermediaries represent the roles played by actors that bridge the domains of supply and use, whereas there may be multiple layers of supply and use relations in the areas of complex technologies such as ICTs. Coordination and building alignment often have been considered to be crucial processes to integrate diverse interests and knowledge towards bringing about technological innovation and change. Yet, the concept of the multilevel game highlights differing commitments and interests, as well as shifting goals and objectives in the dynamics leading to certain degrees of alignment and coordination. Through these diverse arrays of interactions over multiple cycles of innovation arises the development arena; whereas the arena

represents a space where multiple engagements and actions together emerge and evolve through certain linkages.

2.4 Conclusion

This chapter began with an inquiry into how and to what extent the diffusion of a large-scale technological innovation could be managed or directed. The initial problem that led to this inquiry was the gap between vision and the actual uptake of innovations in many technological areas. The problem was conceived as a diffusion problem, often predicated on measuring, predicting, and assessing. Diffusion theories based on economic and sociological points of view have produced models to observe the patterns, modes, and rates of adoption of new technological products and other types of innovation. These have served as useful tools to predict and assess aggregate levels of adoption over time. However, a static view of technology resulted in a partial view of the complex process of technological diffusion.

Although diffusion studies focused on the gap between initial predictions and actual mode and rate of adoption as a problem to be overcome, the SST perspective has rather highlighted the gap between the design and use by offering a stance to look into the complex interactions among the diverse factors and actors that shaped technology to particular use. Thus, the gap represented the inherent source for uncertainties and contingencies of technological innovation and use. Meanwhile, attempts to counteract such uncertainties accompanied efforts to explicate sociotechnical dynamics. Conceptual tools and frameworks including the CTA, SNM, and MLP have been much discussed and advanced with an aim of steering technological innovation and change. Despite the usefulness of these concepts and frameworks in tracing and explicating the process of innovation and diffusion, they fail to demonstrate effectiveness for their prescriptive use. The retrospective mode of describing the aggregate level of interactions refrains from observing individual-level interactions, leading to choices that shape technologies and technological pathways.

In the field of ICTs, the choices are often pursued through building alignments among diverse interests. Standardisation in ICTs highlights such tendencies, as

standards and standardisation are pursued to bring about compatibility and interoperability between technologies, components, operating systems, software, and more. This interoperability implies the need for coordination of multiple interests, while the coordination poses further challenges. Although alignment may be formed through standards, the standardisation process itself entails not only cooperation but also conflict and competition among those who pursue their particular aims and goals in the collective frame of the standard-setting process. Furthermore, implementation and use of standards brings challenges for aligning broader and much more diverse actors and settings towards particular choices.

The social-learning framework lends insight to link supply-side dynamics (e.g., design) with that of the user side (e.g., use), by offering a cyclical model of the process involving design, development, implementation, and use. Although it highlights the gap between design and use, the gap represents a space to learn through the cyclical process of innovation, leading to societal embedding of new technological products and services. Innovation occurs through adoption, and thus through the process of diffusion. The analytical sphere offered by the social-learning framework brings attention to the mediating actions and choices negotiated through the cyclical process of design and use. These actions and choices can be further elaborated through the role of intermediaries and their interactions involved in bridging the domains of development and use. However, varying layers of supply and use can be examined in relation to ICTs, which bring further complexities and uncertainties in the implementation and use of technologies. Yet, the concept of the multilevel game enables mapping of diverging perceptions of the players involved in the process of intermediation. Therefore, not only the interactions leading to certain choices can be scrutinised, but also the perceptions linked to their past choices, present relations, and future outcomes may be examined. This broadens and deepens the scope of analysis whereas the broadened scope is mapped onto an emergent cognitive space that has been conceptualised as the development arena. The complex interactions leading to technological innovation and change may thus be examined through an analytical sphere of which the boundaries are not yet fixed but emerge

and evolve with the diverse linkages that are formed in the process of design, implementation, and use of emerging technologies.

Chapter 3. Research Design and Methodology

3.1 Introduction

This chapter discusses the research design and methodology: how I designed the research to conduct the empirical study, what choices I made in research strategy and method, and how I collected and analysed the data. I delineate the process of designing and conducting the research and justify my choices. Justification of those choices also includes reviewing the strengths and weaknesses of the research design.

Following the introduction, I discuss the research strategy along with the conceptual framework. The choice of research strategy has largely been guided by the SST perspective. SST provides the groundwork on which to carry out a detailed examination of the interactions among the actors and factors that co-shape the process of innovation and uptake of an emerging technology. The detailed examination is further guided by the conceptual framework built on an integrated view of interactions leading to standardisation and domestication of innovation through social learning. The methodological choice led to a single case study on the emergence and evolution of WiBro; I identify the specific case sites accordingly.

The chapter then reviews the processes that led to choosing the methods of data collection as well as the process of collecting and analysing the data. Interviews follow a semi structured method to provide flexibility in the contents of the inquiry. For triangulation of data, interviews were accompanied by analysis of documents as well as observation of seminars and conferences where WiBro was largely addressed. The chapter ends by detailing the process of analysing the data with some reflections on difficulties encountered and how they were managed.

3.2 Research Strategy and Methodology

3.2.1. Research strategy and conceptual framework

This research was inspired by the tradition of STS, and SST in particular (MacKenzie and Wajcman, 1985; Williams and Edge, 1996). The SST perspective guided me to examine the particular processes of innovation and uptake of an

emerging telecommunication technology by scrutinizing the interactions among the various actors and factors involved in the process. I investigated how actors at the selected research settings act, perceive, and engage themselves with their surroundings and the social world, and how this shapes and is shaped by their engagement with the process and the content of technological innovation. I especially considered meanings and interpretations and how they are constructed.

For the research to capture meanings and interpretations the actors give to and take from the artefacts, I adopted qualitative methods involving close contact and interaction with participants in the study. Being a qualitative research, theory can be used as a ground for choosing the methodology and the epistemologies underlying the methodology (Crotty, 1998; Denzin and Lincoln, 2003). Rather than applying a single theory to designing the research, however, I employed a number of theoretical concepts and frameworks in science and technology studies to build a conceptual framework to guide the research. A conceptual framework is useful for delineating the main entity to be studied (Miles and Huberman, 1994). However, the study method may yet be rudimentary and may be refined and further developed along the empirical research.

Based on a critical review of the literature, I developed a conceptual framework to study the process of design, development, and uptake of emerging telecommunication-technology standards and services. This research is built on three major theoretical frames, whilst the SST perspective serves as an overarching framework for the study. The conceptual framework brings together the dynamics of supply-side (e.g., alignments and competition) and user-side (e.g., domestication and appropriation) economics. Although supply-side and the user-side dynamics are conceptually divided into two separate domains, these are integrated by applying the concept of the *development arena* that holds together the interactions among multiple interests, artefacts, locations, and relations (Jørgensen and Sørensen, 2002).
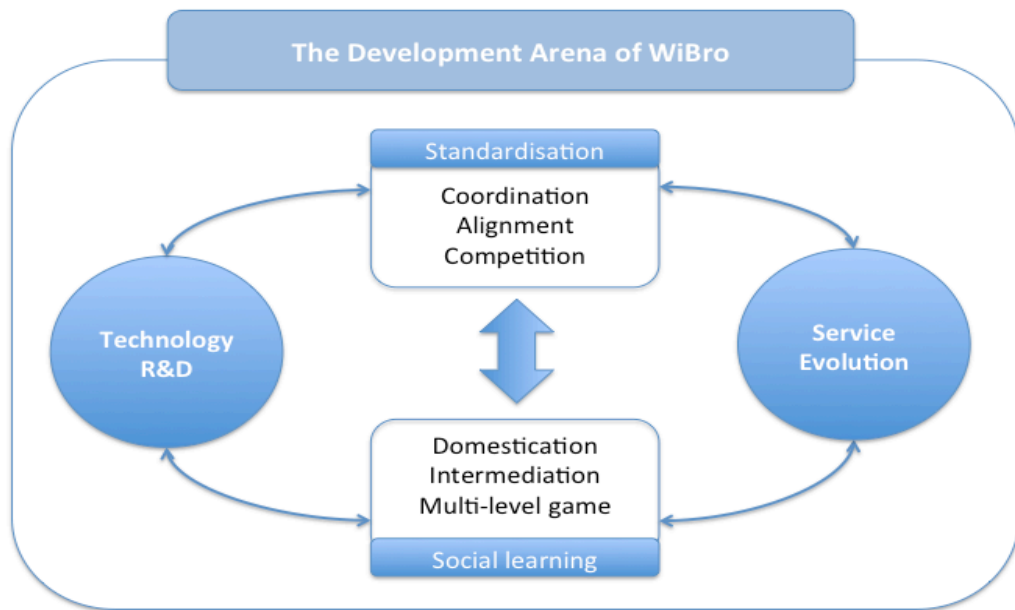
Figure 1 Framework for the Study of WiBro.
(Unless otherwise indicated, figures included in this dissertation were created by
Jee Hyun Suh © University of Edinburgh 2014)

I provide an integrated view of the interactions involved in the standardisation of
ICTs and social learning in technological innovation. Activities linked to
standardisation including coordination, alignment, and competition, observed vis-à-
vis the processes of domestication, intermediation, and multilevel games that
constitute social learning in technological innovation. Through this approach, I
examine the processes of design, development, and uptake of WiBro, leading to
service evolution. Such a framework brings into view initial intentions of varying
interests, their strategic alignments towards the development of an emerging
standard and technology, as well as the shifting choices and relations towards the
adoption. The framework thus guides the reader through a journey toward the
evolution of next-generation telecommunication standards and services.

Although it may have been ideal to consider the wide range of players, including
developers, suppliers, and end-users, this research has sought to explore how this
chain of actual and potential users were represented in the development process by
focusing upon the nested chains of intermediate users such as network operators,
application developers, and other service providers who made use of the
technological components and systems of WiBro. This decision is due, in part, to the

limited scope of time and space given to this doctoral research, which gave little scope to focus down on the appropriation of the technology by 'final users'/consumers in a context in which the main objective has been to observe and examine the varying choices that have shaped the WiBro technology, standard, and service. But more importantly, I seek to broaden the scope of what has often been regarded as supply-side dynamics.

In the field of telecommunications, and in mobile communications in particular, a massive scale of infrastructural development and implementation is necessary, requiring vast investments and knowledge inputs from a diverse arrays of players. Although the dynamics involved in such processes have been widely studied by scholars in varying fields including technology and innovation studies as well as standardisation, these were often regarded as supply-side dynamics. This research employs a more flexible and dynamic view of these interactions by applying the concepts that describe not only the supplier but also the supplier and user relations and aligns the user dynamics with the interactions involved in the process of intermediate-level adoption of the WiBro technology and standard.

3.2.2. Case study

This research applies a case-study method that allows an in-depth examination of the subject matter in relation to its context (Yin, 2009). According to Yin (2009), a case study is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p.13). Further, Michell (1983) defined a case study as a "detailed examination of an event (or series of related events) which the analyst believes exhibits (or exhibit) the operation of some identified general theoretical principles" (p. 192). In this regard, the case-study method should be useful, as the research is based on an empirical inquiry that requires a detailed examination of the lifecycle event linked to the emergence and evolution of WiBro service.

Yet, the aim of this research has been to bring a theoretical inference from the in-depth study of WiBro, thereby contributing to knowledge about managing or addressing innovation and evolution of an emerging technology standard and service.

Generalisation through a case study, however, has been a debated issue among scholars. Although the case study has strength in terms of the depth and intensity of observation, the quantity of data about a particular case this is achieved at by limiting the numbers of cases. The method has often has been criticised on the grounds of its weaknesses in generalisation to a larger population (Blaikie, 2000; Yin, 2009). However, other scholars have argued that the uniqueness of situations can offer the groundwork for logical inference or analytic generalisation (Donmoyer, 2000; Gomm et al., 2000; Stake, 1998). Researchers under the tradition of social construction and SST have resorted to case studies that enabled them to bring about generalisations or general lessons in certain scopes through in-depth analyses of a single or a few observed cases (Russell and Williams, 2002).

Following the key objective of this research study—examining how a collectively driven, large-scale technological innovation could meet or respond to evolving user evolvement—this study required a long time frame (more than ten years) to include the lifecycle of the technology from its birth to its evolution. It thus took on the characteristics of an in-depth single-case study. The rationale for a single case as the subject of this research was on the premise that the South Korean WiBro case is a unique case in that it allows the researcher to observe a phenomenon in relation to the particular history, policy, technology environment, and more. Furthermore, an in-depth examination of the lifecycle of WiBro over time brings the case under the method of longitudinal study, such that changes in the participants in the study may be observed over time. Given the limited time and space for this doctoral research and thesis, the single unit of study in such a depth and length should better serve the purpose of this research, bringing findings that contribute to knowledge and possible interventions in real-life complex situations.

3.2.3. The case selection

To conduct the case study, I selected the single case of the emergence and evolution of WiBro; the definition of the case is equivalent to the unit of analysis (Yin, 2009) encompassing the process of design, development and uptake of an emerging telecommunication technology, and the evolution of technology-based services. The problem space is filled with varying interests including those of the manufacturers,

government, telecommunications-network operators, and application developers. I examined and analysed the interactions and relations among these players based on the conceptual framework discussed in the previous section.

For analytical purposes, I divided the case into three domains according to the timeline of the emergence and evolution of WiBro service: the initial stage of design and development during 2001~2005; the commercialisation and service uptake during 2005~2009; and the evolution of WiBro services during 2009~2013/the present. I divided stages to reflect the processes of design and development, commercial system and service deployment, as well as the on-going evolution of WiBro services. However, such a division may be somewhat arbitrary, as I made that choice deliberately based on my view of the lifecycle of WiBro. In other words, the choice does not indicate that the design and development process ended in 2005. However, the year 2005 marks the end of the three year R&D project of High-speed Portable Internet (HPi). Also, the spectrum licensing for commercialisation of WiBro occurred in 2005. Thus the focus shifts from the stages of research and development to commercialisation, following the key incidents that occurred in the commercialisation.
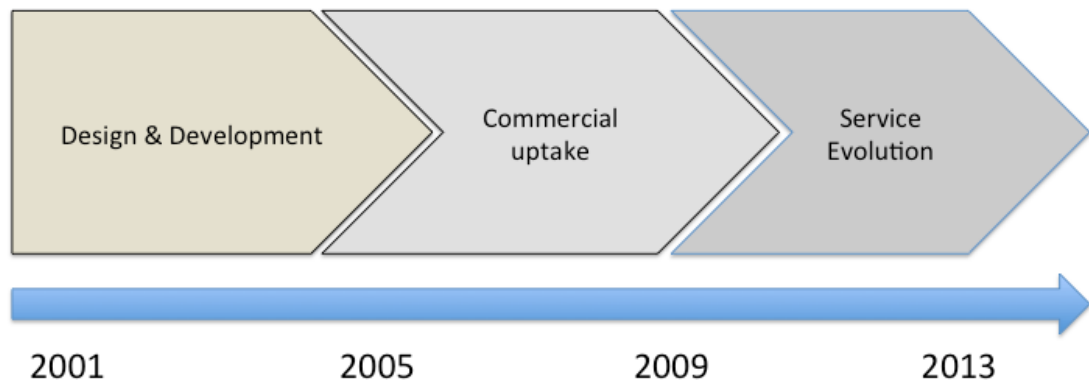
Figure 2 The case of the emergence and evolution of WiBro.

3.2.4. Case sites

The major contribution to technological development of WiBro came from the collaboration of a government research institute, ETRI (Electronics and Telecommunication Research Institute), Samsung, and the two major network

operators, Korea Telecom (KT) and SKT. Although technological development was carried out through a government coordinated R&D program that began as a three-year initiative in 2002, WiBro service was further promoted through the government's IT strategy project IT839 since 2004. The current WiBro service providers are SKT and KT, the two largest telecommunication service providers in Korea. Service providers at the level of applications and content have also taken part in attempts to bring out advanced WiBro services. Furthermore, standardisation has been closely linked to the development of the technology and the provision of services. Standardisation was carried out by Telecommunications Technology Association (TTA), whereas standardisation was later extended to international standard setting through the harmonisation of WiBro with the international standard for WiMAX.

Based on this brief overview of WiBro, the sites for an in-depth case study of WiBro could be broadly categorised into four: i) Hardware Systems and Devices; ii) Standardisation; iii) Network and Platform Operation; and iv) Applications and Content Services. Key innovation players were mapped into relevant areas. The mapping, however, does not suggest clear cut boundaries in the players' roles and interactions. The mapping helps clarify the sites at which data collection would occur.
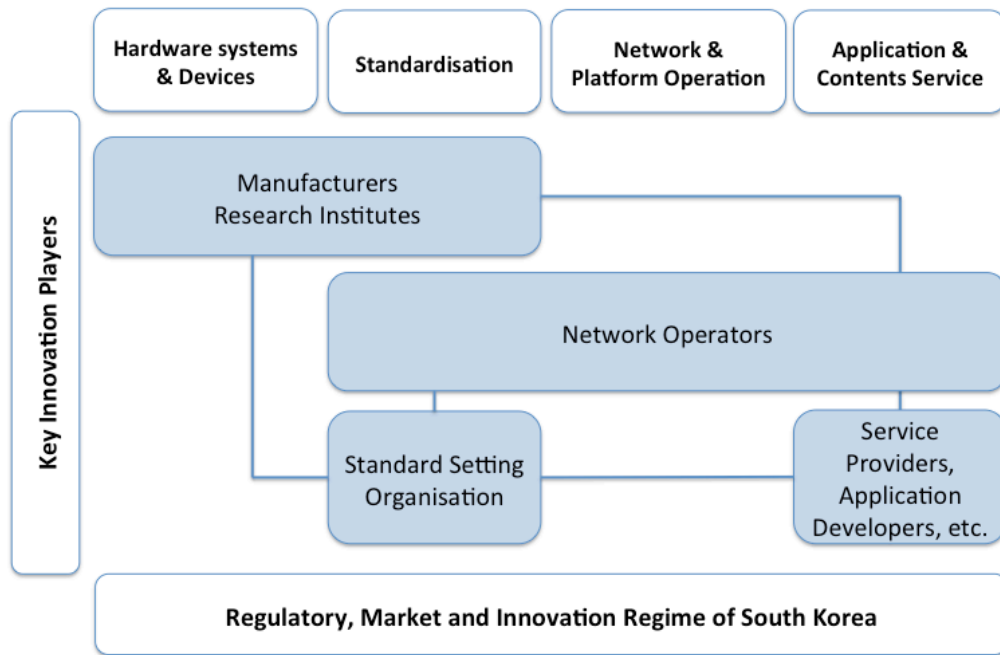
Figure 3 Overview of case sites for WiBro.

3.3 Data collection

Supporting the use of case studies, scholars noted the importance and benefits of using multiple sources of evidence (Blaikie, 2000; Yin, 2009). Multiple sources of data collection included documents, archival records, interviews, observations (direct and participant), and structured interviews and surveys. For this case study on the emergence and evolution of WiBro in South Korea, data collection relied on documents from various sources including government and industry reports, archival records of news articles from 2001 to 2013, 25 semi structured interviews, and direct observation in conferences and meetings that directly addressed WiBro-related issues. Data triangulation enhances the validity of accounts of a particular phenomenon (Yin, 2009). The data from the multiple sources were triangulated to bring valid accounts of the emergence and evolution of WiBro technology as a mobile standard and mobile service.

3.3.1. Semi structured interview

Interviews are regarded as one of the most important sources of data in a case study. Well-informed and well-conducted interviews can provide insights into certain flows of events, as events are composed of human interactions (Yin, 2009). Furthermore,

interviews allow people to "share the world of others to find out what is going on, why people do what they do, and how they understand their worlds" (Rubin and Rubin, 1995, 195p). They may also lead to important sources of data that would not have been identified without insider's knowledge and networks. Therefore, the primary goal for using the interview method is to gain insight into how and what people perceive, learn, adopt, exclude, compromise, or associate themselves with the external environment. For this case study in particular, it was important to discern how different players yielded differing perceptions, understanding, and learning with regard to a subject matter. The several ways to conduct interviews include structured, semi structured, and unstructured interviews. Although consistency is often sought through structured interviews that strictly standardise a set of questions, a case-study interview tends to be better placed with a degree of fluidity in the stream of questions (Rubin and Rubin, 1995; Yin, 2009). In a semi structured interview, a set of questions have been prepared beforehand to guide a consistent line of inquiry, but the questions do not strictly confine the scope of the interview. Therefore, I designed the interview questions for this case study to allow a degree of flexibility to the contents of interviews, while preparing a set of questions in advance to guide the line of inquiry during the interview.

Interview design

Interviews are an interactive process that take place only if there is a respondent who agrees to sit for an interview. This was a primary concern in gaining access to possible relevant interviewees. In the beginning, I made modest attempts to reach people who belonged to any of the case sites I had identified and mapped through personal contacts: friends, colleagues, and family. As most case sites represented major vendors in South Korea, it was not difficult to find a number of personal contacts who were either staff members themselves, working for vendors, or had some relationships with people in the companies and organisations. I arranged a couple of interviews through these contacts in the beginning. I then realised it would be important to gain access to people whose knowledge and experience were directly linked to the case of WiBro. Furthermore, although I assumed a snowball sampling would be ideal, interviewees were generally reluctant to introduce or recommend

others to be interviewed. Upon realising this, I began identifying potential interviewees from WiBro-related publications, newspapers, and government reports. I contacted those who were authors or key references by e-mail. Some replied with a positive response. Others had a negative response to interviewing due to certain job-related reasons. Further, gaining access to key players in the field of WiBro was accompanied by some fortunate encounters while searching and contacting people.

Through these processes, I interviewed 22 people, leading to 24 interviews. Among them, at least 15 could be regarded as key players in the field of WiBro who were exceptionally informative, as they were currently or had been actively involved in at least one area associated with WiBro. Interviews with these participants lasted 2 to 3 hours. For others, interviews normally took an hour. I conducted interviews in 2009–2010 and 2011–2012. As there were much fluctuation in corporate strategies and government policies during these years, it was important to trace the views of the players in relation to time. Yet, changing views were clearly revealed as I collected additional data and triangulated the information with other sources of data. I decided to keep all names confidential, but reveal the positions people held, for those who agreed. Twenty interviews were voice recorded whereas four participants either did not allow me to make a voice recording or their interviews took place in an informal setting. Where I did not make a voice recording, I wrote up the interview content during and immediately after the interview was completed.

The interviews conducted in the field study are listed as follows:

Table 1 Interviews conducted for the case study

Interviewee by Affiliation	Position	Field of Expertise[1]	Interview	Date of interview
Samsung Electronics	Executive director	Marketing	1	4 Mar 2010
Samsung Electronics	Head of dept.	Mobile device	1	2 Sep 2009
Samsung Electronics	Manager	Mobile device	1	2 Sep 2009
Samsung Electronics	Manager	Mobile device	1	2 Sep 2009
Samsung Electronics	Senior researcher	Standardisation	1	29 Sep 2009
Samsung Electro-mechanics	Deputy head	System R&D	2	16 Aug 2009/ 12 Feb 2012
ETRI	Director	System R&D	1	31 May 2010
University (TTA)[2]	Professor (Head)	Standardisation	1	15 Oct 2009
KT	Director	Standardisation	1	16 Oct 2009
KT	Manager	Network R&D	1	2 Apr 2010
KT	Assistant manager	Network R&D	1	2 Apr 2010
KT	Senior researcher	Network R&D	1	10 Sep 2009
KT	Director	Marketing	1	27 May 2010
SKT	Director	Corporate policy	1	13 Sep 2010
RAPA[3](Thrunet)	Director (Director)	Spectrum licensing	1	26 May 2011
Department of Knowledge & Economy (MIC[4])	Secretary	Government policy	1	14 Oct 2009
National Assembly Research Service	Head of Dept.	Government policy	1	21 Dec 2012
Hyundai Heavy Industry	Head of Dept.	Application	1	10 Feb 2010
Hyundai Heavy Industry	Deputy head	Application	2	5 Feb 2010 10 Feb 2010
Hyundai Heavy Industry	Staff	Application	1	10 Feb 2010
Hyundai Motor Company	Manager	Application	1	19 May 2010
MODACOM	CTO	Mobile device	1	15 Jul 2010
SeAH(POSDATA)	(Chief engineer)	System R&D	1	28 May 2010

---

[1] Field of expertise generally complies to the role or departments the interviewees belonged to while the fields were re-categorised by the researcher.
[2] Former affiliations and positions were written down in brackets. TTA stands for Telecommunications Technology Association.
[3] Korea Radio Promotion Association.
[4] Ministry of Information and Communication.

I prepared an interview guide of guiding questions in the beginning, prior to
conducting interviews. I modified the guideline at least three times during the early
stage of interviews, changing the questions, clarifying the questions as more
interviews took place. Based on the guiding questions, I reselected and expanded the
content of questions depending on the interviewee's main area of expertise and
interest. The following table shows the initial categories of questions and the list of
questions that guided the interviews.

Table 2 Guideline to interview questions

Stages	Questions
Introduction & Personal question (Rapport)	- Introduction to interview - Would you please explain your current role? - What is your relation with WiBro?
Organisation	- What are your organisation's roles with regard to WiBro? - How and when was your organisation first involved with WiBro? - What was the initial aim of your organisation with regard to WiBro?
R&D	- What area of R&D are you/your organisation involved in? - What were the key visions of WiBro, and what are they now? - What are your perspectives about the key drivers of R&D? - What are your perspectives about "home-grown" technology?
Commercialisation	- What were the attempts and interests of your organisation regarding the initial launch of commercial product/service? - How are your products/services being prepared and what are your strategies? - What is your perspective on the current mode of market adoption of WiBro? - How would you respond to the government's "WiBro Vitalisation Policy"?
Standardisation	- How is your or your organisation's role related to standardisation? - What are your perspectives on standardisation of WiBro/IEEE802.16e? - How would you describe the relationship between WiBro and Mobile WiMAX(IEEE802.16e)? - Have you participated in any of the standard setting meetings (e.g. TTA, IEEE, WiMAX Forum, ITU) and what were your experiences?
Technology & Service Evolution	- How is WiBro technology/service evolving? - What is your/your organisation's present and near future plan regarding WiBro service? - How do you expect WiBro technologies/service will evolve and why? - What are your perspectives on the role of government with regard to current and future WiBro?

Interview process

Seeking and matching relevant interviewees was not an easy process, yet interviewing various people who work in different fields of expertise and have differing views required careful planning and sensible decisions on what to ask and how to ask. However, much of this skill was acquired through the process of interviewing, especially by reflecting on previous interviews. Interviewing is a conversation involving questioning, listening, and answering in a dynamic and iterative process (Rubin and Rubin, 1995; Warren, 2002). The iterative process involved ongoing feedback and adjustment. However, when interviewing people around the issue of WiBro, of foremost importance was to discern participants' views aligned with the turbulence of the rapidly changing environment of telecommunications.

Most interviews took place in 2009–2010, when expectations about the evolution of WiBro technology and standard were further heightened, yet faced with varying challenges in the commercial domestic market of WiBro. WiBro was generally being weighed against two different values: the commercial uptake of WiBro service in the domestic market, and its ongoing success in international standardisation and its future outlook as the fourth-generation technology standard. Because of its low market diffusion, questions ensued about WiBro about past, present, and future decisions: What caused the low adoption rate of WiBro? and What are the policy measures for driving the diffusion of WiBro? However, these societal issues were hotly debated, I sensed these questions should not be asked directly during the interviews. It also seemed important as an interviewer to keep a neutral stance toward the debated issue. Although having a "neutral" stance in interviewing is also a debated matter in qualitative methodology (Holstein and Gubrium, 2004; Rapley, 2001), I tried to resolve this problem by focusing interview contents on interviewees' areas of expertise and knowledge. However, I refrained from using some key terms such as "low diffusion" and "failure of WiBro" to avoid bringing the interview to a mode of debate.

My identity as a student seemed to carry more advantage than disadvantage in delving into matters that were most actively debated. Although interviewees seemed to be careful about the subject of inquiry, they tended to greet a student who wanted to learn about WiBro. Some clearly stated they were willing to help a student although WiBro carried some sensitive issues in corporate strategy. As this research addressed issues related to varying fields including research and development, standardisation, policy and the market, it was indeed helpful to discern their views and perspectives without having a particular affiliation that could limit the scope of inquiry and their answers. The strength of collecting data through interviews was increasingly realised as the interviews progressed.

The iterative process of learning through interviews included bringing knowledge and information from other sources to make the learning process more productive. This was done by building up a chronological order of events related to WiBro, based on news articles published online during the period 2001–2010. I followed up with the news beyond 2011 as the research process continued. Because the case study focused on a contemporary topic, I benefited a great deal from being able to meet the participants of the ongoing development and commercialisation of WiBro, as well as those who had taken an active role in the near past. Also, I interpreted the interviewees' sincere responses and involvement in often time-consuming interviews as reflecting their concerns about the past, present, and future of WiBro and beyond, based on each person's knowledge, expertise, and occupation.

3.3.2. Documents and news archives

In this study of WiBro, documents were quite an important source of data, especially to increase the reliability of the methods by triangulating the data (Yin, 2009). I collected documents from various sources including Internet websites, online databases provided by government institutes, and national libraries. The National Library of Korea in particular, has been a key data-collection site, particularly for government publications. A few important publications, especially those about the early stages of WiBro development, were unavailable as online documents and could be accessed by visiting the National Library of Korea.

The initial gateway to document sources, however was the Internet. Using the major search engines of the Internet, I found and bookmarked WiBro-related websites, webpages, formal reports, and informal articles such as blogs. By first reviewing these data, I gradually gained information on WiBro and initiated more focused searches as I acquired knowledge about WiBro. I searched for and identified documents that help build more credibility for the information I had initially gathered. If informally written information seemed important, such as official records of related issues or events, I searched and collected them. I collected documents in three categories: government reports including reports published by government institutes, official documents and articles provided by the industry, and special-section journal articles mainly addressing key issues of WiBro. I describe these in detail below.

Official reports from the Government and Government Institutes

I collected officially published WiBro policy reports and research reports from government websites as well as websites of major institutions including the Electronics and Telecommunications Research Institute (ETRI) and the Korean Information Society Development Institute (KISDI). ETRI and KISDI played key roles in yielding information on WiBro-related issues including the future prospects of WiBro service, spectrum licensing policy, and promotion of WiBro commercialisation. ETRI reports were focused on economic analysis of future prospects of WiBro service, linked to the R&D activities carried out by R&D departments at ETRI. KISDI's reports related more to issues for policy making; its research outcomes were generally used to make policy decisions at the level of the Ministry of Information and Communication, and later, the Korea Communication Commission, after the restructuring of the government organisation. Earlier official documents on the initial conceptualisation of WiBro during the years 2001 and 2002 were accessed in the National Library of Korea in onsite visits.

Industry reports and society journal articles

Industry reports comprised a small portion of document data. Industry reports that could be accessed online were only those reports published by consultation firms and

banks. However, two major organisations published opinions and plans by industry members related to the development and commercialisation of WiBro: the Korean Institute of Communications and Information Sciences (KICS) and TTA. KICS is a journal society in the field of ICTs. In particular, key documents related to industry plans for spectrum licensing have been very valuable in this research, collected from the journal database of this organisation. KICS-published journals include a number of publications related to WiBro, and the organization held major conferences on WiBro. TTA is a nongovernment and nonprofit organisation for ICT standardisation, a key standard-setting organisation in South Korea. TTA publishes reports and journals on standardisation in addition to organising standard-setting meetings and many other domestic and international activities related to standardisation. Articles on WiBro standardisation written by the members from the industry could be accessed on TTA websites.

News archives

Although the major issues of WiBro could be studied through reports and journal articles, it was indeed important to follow up with the general history of WiBro. Although the empirical case study of this research began in 2009, initiation of WiBro dates back to 2001, the year when the initial report on conceptualising WiBro technology was published. To track down the history of WiBro, I collected news articles from two major news publishers on telecommunications: *The Digital Times* and *The Electronic News* . Initially, I searched articles at each online news site using several key words relevant to WiBro: Portable Internet (the former name of WiBro), IEEE802.16e, and WiBro. However, not only did search results number beyond the scope of this research, but also it was too time consuming to consider reviewing and selecting the articles that would meet the purpose of the search. Thus, instead of directly searching the original news sites, I used the database of electronic technology-related news provided by the Electronics Information Center operated by Korean Electronics Technology Institute. During the fieldwork, I retrieved more than 900 news articles, searching on the keywords WiBro and Portable Internet. Based on the articles, I put major decisions, events, and activities related to WiBro in chronological order. Through this process, I prepared a chronicle of WiBro that

played a crucial role in this research, providing an overall history of WiBro including activities, policy decisions, and events held by key innovation players from the beginning of the conceptualisation of the technology and service. I updated it continuously over time to include the current news and events related to WiBro. Thus, it was a key source for getting information and knowledge about current situations and trends of WiBro-related issues during the research. For accuracy, I triangulated information on important events and decisions with other documents and newspaper articles.

3.3.3. Observation in symposiums and conferences

Another key method for collecting data was a form of direct observation by attending meetings and conferences where the issues of WiBro were directly addressed by key innovation players. During 2009–2011, WiBro was one of the key issues in the evolution of mobile technologies and mobile services. Issues were also addressed through public conferences, symposiums, and seminars. Following is the list of conferences and seminars that were particularly relevant to my research and that provided helpful resources.

Table 3 List of conferences and meetings attended for research

Event name	Date	Organised by
Next-generation Mobile Communication Technology and Industry Trend Seminar	20 August, 2009	Korea Electronics Technology Institute (KETI)
The 3rd Communication Vision	24 September, 2009	MegaNews, ZDNet Korea
4G Communication Technology Core Technology and Evolution Strategy Symposium	29 October, 2009	Korea Institute of Communications and Information Sciences (KICS)
The 4th WiBro Convergence Service Technology Workshop	4-5 March, 2010	Korea Institute of Communications and Information Sciences (KICS)
The 5th Communication Vision: Outlook on the changes in Mobile Ecosystem and Business in the 4G era	27 September, 2011	MegaNews, ZDNet Korea

I was invited to two meetings by two interviewees they thought would be relevant for my topic of interest. The meetings primarily addressed issues related to WiBro. At these sites, key industry players publicised their current and future strategies.

Oftentimes panel discussions also provided valuable sites for observation. Panels were comprised of speakers from key vendors, operators, and government institutes that were deeply involved in the development and the commercialisation of WiBro. Discussions were normally led by a convener, asking a set of questions to the panel; responses led to other responses and active discussions. Questions were also asked from the floor and answered by the relevant panelists. I tape recorded, transcribed, and translated panel discussions; the data provided valuable information and insights about the players from varying fields.

3.4 Analysis of Data

3.4.1. The process

The process of analysing the data began with the interview and observation data that were normally recorded, transcribed, and translated from Korean to English. To retain feelings and senses from the original interviews, I kept Korean versions side by side with English versions as I coded. As I collected the primary data through interviews, symposiums, and conferences, I transcribed data on the day of the event. While reading the transcript, I also noted nuances such as a particular term or a particular moment, sites for further inquiry, and evaluative comments. This was a process of brainstorming from the data before placing them into a form appropriate for structured analysis such as coding and categorising.

The process of analysing the data did not follow any strict form of data analysis, as there was no clear rule that directs and guides the analysis of qualitative data (Spencer et al., 2003). The analysis, however, was heavily involved in a conceptual process and thus resembled the method of grounded theory (Turner, 1981). Several rounds of applying concepts and categories to data took place that would have represented the process of coding. A sequence of the process follows:

1. Prior to entering into the process of coding, all the data collected from the interviews and observations were put into one place: a single file that would allow a continuous flow of data, yet unaltered by additional categorisation, other than their original boundaries, as individual interviews or observations. I highlighted parts of data, wherever

comments were added. I read these data several times, adding and editing my comments. This served as a brainstorming process which prepared me for coding.

2. Then, I coded the highlighted parts by applying certain labels, concepts, or categories. Many of these reflected the concepts from the theories on which the conceptual framework had been built, as well as the research questions. Where an immediate application of these conceptual labels and categories seemed inadequate, I included a simple description or summarising term.

3. The third process involved what Dey (1993) explained as the process of classification. The labels, concepts, and categories coding were recategorised into fewer groups. Such a grouping required a careful recategorisation process so as not only to meet certain criteria for allocating data, but also to place categories in certain directions in my mind. This was a complex iterative process as the direction itself was also being formed through categorising, although it was also guided by the research framework and the research questions.

During this process I did not directly include the data from the documents. The documents however, provided context to devise interview questions and relate the answers to certain contexts. Once the categorisation of the data was completed, I used the documents data as important resources to further enhance clarity and validity in the logical flow of analysis.

Documents included government policy reports such as whitepapers published by the former Ministry of Information and Communication, project reports submitted to the government by the organisations that had undertaken WiBro-related research projects, industry reports, and TTA and KICS journal articles that served as important resources for industry strategies. The contents of these documents could be regarded as "social facts" that "are produced, shared and used in socially organized ways … and construct particular kinds of representations with their own conventions" (Atkinson & Coffeey, 1997, 47p). Thus, although many of the "social

facts" were contained in documents, they were triangulated with other sources of data to build the credibility of the findings of the case study. Furthermore, the documents were particularly helpful in analysing the changes in various aspects of WiBro over a little longer than a decade's time. The contents reflected the particular state of time, marked by their publication dates, and in some aspects, they were more reliable than some retrospections made by interviewees about past incidents. Nonetheless retrospective comments by interviewees were credible. Oftentimes, interviewees' comments on past incidents and about the changes they acknowledged had the powerful role of confirming what could have only been conjectured through documents.

3.4.2. Reflections and managing difficulties

Studying a contemporary issue undergoing continuous, yet rapid changes in its status made it difficult to see at which point the data analysis should stop. One of my main interests in the research had been to observe how WiBro service developed along the evolving technologies and society as a whole. It was difficult to discern when and how the research could be detached from the field for the complete analysis of the field data. Rather, the data analysis seemed to be continuously influenced by the incoming data, even until late 2012. Although formal data collection was completed by 2011, major events were still occurring during 2012 and 2013 – although much infrequently than before - that seemed to have a degree of impact on the evolution of WiBro service. Inclusion of these latest data would indeed make a significant difference to the research; I took them for further analysis and wrote the last section of this thesis based on the analysis.

In fact, the "end" or "outcome" of WiBro was an issue from the inception of the project. From 2009 on, many had already concluded that WiBro was a "failed" technology, successful in its development yet failed in commercialisation. Many interviewees during 2009 and 2010 were interested in seeing this research on WiBro play a role in either finding the causes for the failure of a large-scale government-driven technological innovation or in suggesting the direction for future innovation policy. During the process of analysing data, it was indeed difficult to justify keeping the research stance away from the largely presumed "result" of WiBro. It was by

strengthening the theoretical framework and making it more robust through data analysis that the research could overcome the dominant discourse on the failure of WiBro.

The following quote seems to suggest the value of research that does not share a common ground for the search but seeks to find a coherent set of relations and interactions:

> The goal is *not* to produce a standardized set of results that any other careful researcher in the same situation or studying the same issues would have produced. Rather it is to produce a coherent and illuminating description of and perspective on a situation that is based on and consistent with detailed study of that situation.
>
> (Ward-Schofield, 1993, 202)

Many potential readers of this thesis may indeed be seeking findings that may be rather generalisable to their concerned field of interest. Thus, I shall seek the juncture to eventually communicate with these potential readers about the findings and the implications of this research.

3.5 Conclusion

In this chapter, I discussed various choices that led to designing and conducting this research, from the choice of its theoretical grounding and research scope to various methodological choices. Both conscious choices and a degree of serendipity have shaped the path for the research. Therefore, this research design has been the result of choices shaped through the process of this research.

The general framework for this research design was built on the SST perspective, which guided the detailed examination of the process of emergence and evolution of WiBro technology standards and service. Conducting a single case study provided the width (length of time) and depth (detailed examination) of this research and has thus enabled me to explore the complex dynamics of the process involving the design and the appropriation of the emerging technology of WiBro.

A single-case study may have inherent weaknesses that may be practically applicable to the current concerns linked to the case of WiBro. However, this research design has been primarily aimed at explicating unrecognized dynamics while seeking to link what could be observed to enhancing understanding about the co-shaping of technology and society.

Chapter 4. Emerging arenas of coordination towards technological innovation and change

4.0 Introduction

This chapter discusses emerging arenas of coordination towards technological innovation and change. Emerging arenas are observed through the lens of the social shaping of technology (SST) perspective, which offers a basis to observe the complex interplays and evolving relations among the diverse array of players. The term *arena,* in a sense, alludes to the '*development arena*' (Jorgensen and Sorensen, 1999; Jørgensen and Sørensen, 2002) that "holds together the settings and relations that comprise the context for product or process development" (Jørgensen and Sørensen, 2002, 198p). It is a cognitive space where a number of actors and factors are involved in dispersed activities that reflect the relational, unstable, and heterogeneous character of the space. In this thesis, emerging arenas involve various interactions and relations that lead to the design and the development of an emerging wireless broadband technology, WiBro (Wireless Broadband)[5] in South Korea. The scope of an arena has been extended beyond a metaphor that implies a single physical location, to encompass a number of linked sub-arenas that emerge through interactions among diverse players with differing backgrounds and knowledges towards a particular vision or visions. The process of formation and the evolution of a development arena of WiBro is thus explicated through the emergence of sub-arenas that evolve to together constitute the development arena of WiBro.

WiBro emerged as one of the key candidates for a next generation mobile communication technology and service around the early 2000s in South Korea, especially marked by features directed towards the transition to fixed and mobile convergence in telecommunications. The dissertation as a whole looks into the dynamics involved in the process of the design and development towards the commercial uptake and the evolution of the emerging communication technology

---

[5] WiBro was originally named Portable Internet. MIC changed the name to WiBro meaning Wireless Broadband, as it was promoted through its innovation policy in 2004. Throughout the thesis, names correspond to the time of its use. Thus, Portable Internet is used during 2001–2004, WiBro from 2004 on.

and services. This chapter mainly focuses on the initial formation of the momentum that enabled and evolved towards the development and the uptake of an innovative technology. Momentum is observed through a processual approach that follows a series of interactions among the involved actors and factors. In particular, the emergence and shaping of alignments are observed as they are coordinated and evolve through a particular path of technological innovation. The term *alignment* describes the coming together of and forming close relations and interactions among the players in pursuit of a particular vision or visions. Alignment has been used by Molina (1997) along the concept of *sociotechnical alignment* to denote a process involving interactions of technical and social factors and actors, of which quality and effectiveness become the key factors for successful technological implementation (Molina, 1997, 604p). However, in this research, the term alignment does not necessarily imply such normative means for successful technology implementation, whereas its impacts may be pursued at the level of individuals who pursue alignments. The processual approach to WiBro case rather demonstrates incompleteness of an alignment: an alignment that is formed and sustained through multiple players while their immediate goals and commitments vary. Alignment thus denotes a form of strategic relations and interactions which evolve as players adapt to and learn through complex and contingent processes of technological innovation.

This chapter is comprised of three main sections, each examining the coordination of alignments that have emerged and evolved through interactions among diverse actors and factors towards the development of an emerging telecommunications technology in the early 2000s in South Korea. The first section examines the dynamics that led to the initial conceptualisation of the technology through the shaping of spectrum use in the 2.3GHz frequency band. The second section observes the initiation of a large-scale national R&D program in which WiBro system technologies were designed and developed. In the third section, an emergence and the shaping of WiBro standard is examined as it coevolves in relation to other emergent arenas of spectrum and R&D, as well as extended relations towards global standardisation.

The story of WiBro begins with the rapid diffusion of fixed-line broadband Internet in South Korea around the year 2001. The number of subscribers for the fixed-line broadband Internet increased from 370,000 in 1999 to 4,020,000 in 2000, and to 7,810,000 in 2001, exceeding ten million subscribers by October 2002 (MIC, 2002, p17). The rapid diffusion of fixed-line broadband Internet and its use gave rise to the industry's demand for wireless data-communications services, whereas the trend outlook suggested gradual shifts from voice to data, and from wire-line to wireless services. An ultimate vision was then the convergence of fixed-line and the wireless[6] (MIC, 2002, p18).

The reshaping of the spectrum in the 2.3GHz frequency band occurred in such exigencies of the telecommunications market and industry in South Korea. The spectrum in the 2.3GHz frequency band, which had low use, was problematic, and was redesigned for other uses to raise the level of efficiency and finally reallocated to Portable Internet (WiBro) use. This section delineates the process of such reshaping of the spectrum in the 2.3GHz frequency band; the process led to the conceptualisation of an emerging wireless broadband service along the regulatory decision, upon reallocation. First, the chapter discusses the process of interactions among various players that led to the emergence of coordinated alignments towards the shaping of the 2.3GHz frequency band. Second, it examines how the generic vision of WiBro was shaped through interactions among involved actors. Third, it further observes the conflicts and disputes among differing interests and how they were addressed.

4.1.1. Initiation of a coordinated arena

The dominant service in the 'wireless' market had then been the mobile telephony, whereas issues related to wireless LAN-based Internet access were slowly arising and driving changes in certain regulatory and industrial fields of

---

[6] In the Report (MIC 2002), the term *wireless* in Korean largely denoted mobile communications while including the wireless LAN.

telecommunications.[7] The wireless LAN-based Internet operated on the 2.4GHz frequency band. The International Telecommunications Union Radio communication Sector (ITU-R) defined the band as relegated to *industrial, scientific and medical (ISM) applications*. In Korea, commercial wireless LAN-based Internet access services were officially launched in 2002 as the Ministry of Information and Communication (MIC)[8] allowed for the unlicensed operation of commercial wireless Internet service by telecommunications service providers in June 2001.

Subsequently, major broadband carriers, including KT and Hanaro Telecom, began preparing for commercial wireless LAN-based Internet services on the 2.4GHz ISM band. Yet, Thrunet,[9] then the third largest fixed-line broadband carrier in the market, initiated a plan for a new wireless business addressing certain limits and challenges on the ISM band. Thrunet's intention was to overcome the limits of the existing wireless LAN service and provide wider coverage of wireless Internet access with higher performance(Chung and Lee, 2002). It was expected to complement fixed-line broadband Internet access service while leading to the generation of new revenue with fixed mobile convergence (Back, 2001). In pursuit of such advanced wireless LAN-based Internet service, Thrunet searched for an available frequency band, which ultimately led to the request for reallocation of a poorly used frequency band adjacent to the currently available ISM band (Interview with former team leader at Thrunet, 26 May 2011).

In line with an attempt to secure a new spectrum band, Thrunet raised an issue to the government about the inefficient use of the spectrum resource at the 2.3GHz

---

[7] The Korean government, Ministry of Information and Communication allowed for commercial wireless Internet service in the unlicensed ISM band after a degree of debate on the possible use of the band by telecommunications network operators. (http://www.etnews.com/news/detail.html?id=200106260260)

[8] The Ministry of Information and Communication (MIC) and Korean Broadcasting Commission (KBC) were later consolidated to form the Korea Communications Commission (KCC) in 2008. This thesis has followed the names of the organisation in accordance with the corresponding dates.

[9] Thrunet was the first high-speed Internet service provider in South Korea, starting service in July 1997 followed by trial service in November 1996. Thrunet merged with Hanaro Telecom on 1st January 2006. The interviewee served his position as a team leader in Thrunet until he moved to Korea Radio Promotion Association (RAPA) in 2003.

frequency band that had been allocated for Wireless Local Loop (WLL) [10] service. Although the 2.3GHz band was already in use, the band had attracted Thrunet's attention for a number of reasons. These were openly mentioned by an interviewee who had been involved in the initial stages of conceptualising WiBro. First, unlike the ISM band, only a small shift of 100MHz towards the licensed 2.3Ghz band would allow wireless access to Internet with high-powered, low-cost wireless LAN equipment. Second, there was additional space of 40MHz available in the 2.3GHz band, which had been set as the guard band between the bands allocated to KT and Hanaro Telecom. Thrunet could have aimed at this guard band. Third, despite the spectrum being an invaluable resource for radio communications, the 2.3Ghz spectrum band was being underused, as the actual market demand for the WLL service had been quite low. Fourth, it seemed the 2.3GHz band was relatively higher band than those preferred by mobile operators, thereby carrying little possibility of unnecessary competition with mobile operators (Interview with former team leader at Thrunet, 26 May 2011).

Having been attracted for a number of reasons, Thrunet first submitted a document in the form of a civil complaint, raising an issue of inefficient use of the frequency band (Interview with former team leader at Thrunet, 26 May 2011). The focus was on the spectrum resource being far too wasted by WLL service, which had secured only a small number of households as subscribers to the service. The interviewee from Thrunet recalled as follows:

> KT and Hanaro were using 60MHz and there was the 40MHz guardband. We could have asked for the 40MHz since KT, Hanaro, and Thrunet were the three major broadband carriers, and Thrunet was the only one that had no spectrum resource allocated. However, we thought only 130 households using the 100MHz bandwidth wasted the spectrum, and requested that the

---

[10] WLL had been offering wireless service between the subscriber and the landline telephone network—the public switched telephone network (PSTN)—thereby bringing efficiency to the deployment and the implementation of the fixed-line network. However, WLL service was limited to voice and low-speed data communications, which made its use less viable for wide diffusion in the mass market due to the already saturated market for telephones as well as the emergence of advanced high-speed network systems and services including ADSL and CATV (MIC 2001, 4p).

spectrum be returned and reallocated. … I think it was around July 2001, we submitted a document in a form of a civil complaint to the government. It was a bit risky to do that, as a telecommunications service provider to submit such a document and request to the government to reallocate the spectrum. Anyway, we did, and it was reviewed through research groups. … At that time, the officer in charge of spectrum at MIC had a great interest in this, and he suggested that a research group be formed and seriously go over the matter and carry out research on how to make efficient use of the spectrum.

(Interview with former team leader at Thrunet, 26 May 2011)

Initial alignment was thus formed between Thrunet and MIC towards considering the regulatory decision on the use of the 2.3GHz frequency band. Yet, Thrunet's main interest was in securing the spectrum resource whereas MIC's objective had been to enhance efficiency of spectrum use.

Upon MIC's approval in reconsidering the existing use of the 2.3GHz band, a research group was organised through and facilitated by the Korean Radio Promotion Agency (RAPA)[11] whose main role included ensuring and promoting effective use of radio resources, based on the Korean Radio Act for efficient management and promotion of the radio spectrum. MIC had an advisory role whereas participants were relevant industry players including KT, Hanaro Telecom, Thrunet, and system manufacturers. The research group was given the role of raising suggestions on possible ways to promote efficient use of the 2.3GHz frequency band.

Yet, the research group was immediately divided into two groups: one group comprised of existing 2.3GHz band license holders for WLL service: KT, Hanaro telecom, and a WLL system manufacturer, LG Electronics; the other group included Thrunet and wireless LAN-related system manufacturers. As the report commented,

---

[11] Korea Radio Promotion Association(RAPA) was founded in 1990 based on Korea Radio Legislation Act #66. RAPA is a legal entity representing affiliated members of the Korean Radio Industry. RAPA works with businesses, academics, institutes and government agencies on various fields including R&D and technology standardization, and has a great role in supporting the government in making its radio-related policies by providing relevant information garnered from every stratum of the wireless industries. (http://www.rapa.or.kr).

the separation of the research group into two differing discussion groups was intended to efficiently reach a resolution between the two differing positions in the short period of 2.5 months (MIC, 2001a). In fact, the two groups represented incumbent fixed broadband carriers whose positions and concerns differed to a degree. KT and Hanaro Telecom were keen to secure their existing rights on the use of the 2.3GHz band whereas Thrunet was trying to enter the licensed band. However, the task of the research group was to provide a unified optimal solution to bring about efficient use of the 2.3GHz frequency band spectrum.

Each group had six consecutive meetings during which two different proposals were prepared. At the seventh meeting, the separately prepared proposals were merged to produce formal recommendations by the search-project group. The recommendations did not produce a concrete vision of the service to be implemented in the 2.3GHz frequency band. However, they suggested the basic framework for a next-generation telecommunications service on which the fixed broadband carriers came to agree. Recommendations included the following: i) the use of the band should not be limited to voice and low-speed data service, but needed to be extended and transition towards high-speed data service, including voice; ii) the system should enable semi mobile[12] service, whereas the technical solutions should include Time-Division Duplex (TDD) to enhance spectrum efficiency (MIC, 2001a, 72p).

4.1.2. The negotiated space: Towards the shaping of a generic vision

The recommendations produced by the research group were a partial vision of future wireless service, incomplete in the conceptualisation of new wireless service that would bring about efficient use of the 2.3GHz band. In fact, the competing perspectives of the existing license holders and Thrunet had not yet been fully reconciled, despite the recommendations reached as a result of the coordination of the research project through RAPA. Thrunet was the third-largest fixed broadband carrier, yet it had not secured any spectrum resources through a license. Thrunet's main intention was thus to seek a licensed spectrum band for its use on the existing wireless LAN standard. Such a path seemed to Thrunet as the most cost-effective,

---

[12] 'Semimobile' service would allow limited mobility to the end-user terminals up to the vehicle speed of 20Km/h (MIC 2001, 51p).

practical, and immediate solution for offering more advanced, high-performance wireless Internet access service. More importantly, it would lead to what they regarded as fixed-mobile convergence.

> We went with this concept in the beginning. Fixed line broadband (in Korea) was the world's best. The backbone network had been implemented in double or triple layers that it could have been too much of a waste. But with regard to the wireless network, mobile communications could provide only a kilo bps data rate, whereas even this wasn't properly used, due to the high cost of use. So if we provided the last-mile solution by connecting AP to the backbone network, this could be one way of fixed-wireless convergence.
>
> (Interview with former team leader at Thrunet, 26 May 2011)

However, KT and Hanaro's approaches were different. They were the current license holders of the frequency band as well as the leading broadband carriers whose interests lay in securing their license rights by conforming to the government's intention, while suggesting a service that would shed light on the future fixed-line broadband industry. KT, the nation's leading fixed-broadband carrier entered the coordinated arena of the 2.3GHz frequency band with the following intention:

> KT was centered on fixed-wire business. So there had always been the potential necessity for going towards the wireless business. At that time there existed a technology or service called BWLL—2.3GHz Broadband Wireless Local Loop. It was kind of a wireless high-speed Internet as a kind of substitute for wire-line high-speed Internet. KT was providing the service. But the usage was low. There was only a small number of subscribers. The government probably thought it was a waste of spectrum. So instead of idling the BWLL band, WiBro … a wireless technology using advanced technologies such as OFDM [was introduced]. KT played a leading role in suggesting to the government the technology initially named Portable Internet.
>
> (Interview with Director at KT, 27 May 2010)

KT, as the incumbent largest fixed-wired broadband carrier, was indeed more keen on securing the spectrum for advanced wireless service that would lead to future fixed-mobile convergence. Although the three leading fixed broadband carriers' interests were aligned towards expanding and initiating the wireless business, their interests did not fully coincide in the methods of using the spectrum. KT and Hanaro Telecom wished to bring the spectrum for advanced yet more challenging service with enhanced mobility that would lead to the next generation of fixed-mobile convergence service, whereas the current licensees of the frequency band and leading fixed-broadband carriers KT and Hanaro Telecom were more inclined towards a service conceptualized and proposed as the 'Next-generation fixed-mobile Convergence System' (MIC, 2001b, p36). The concept of the Next-generation Fixed-mobile Convergence System was a technology solution based on an IP (Internet Protocol) network where the data packets would be transmitted along the IP. Also, limited mobility could be provided through portable terminals. Using TDD as the transmission scheme, the maximum transmission speed would be between 2~5Mbps (MIC, 2001a).

Although Thrunet's vision had initiated the dialogue for better use of the 2.3GHz band, differences and opposition to the initial envisioning of the spectrum's use emerged during the course of reshaping of the spectrum band:

> The initial business proposal we had in mind began with the thought that there was no wireless high-speed data service, despite the presence of a wire-line high-speed network. At that time, 2G could only provide some Kbps speed. It could only enable messaging service. We suggested we go with the service model based on IEEE802.11b. At that time, even IEEE802.11a had not been completed. … The system cost was low, and if we could shift just 100MHz towards 2.3GHz there would be no problem with radio frequency. If operators could use this, we could bring the low-powered wifi system to high-powered (low-power meant 10MW per MHz, which could be used without the government's permission). Then, existing AP could be used for indoor use, and for outdoor use high-power systems could be implemented to provide extended coverage up to 300 to 400 meters, whereas the low-power

system permits only around 100-meter coverage. The fixed-line high-speed
network had been very nicely built with optical cables and others, but people
still had the inconvenience of having to find the wire-line all the time. As a
solution to the inconvenience in the 'last mile,' we proposed the service
while positioning it as 'nomadic' type, enabling wireless access to the
Internet at a speed range still to the low speed of a moving vehicle such as
buses. In the beginning this was quite persuasive. But Hanaro and KT's
thoughts were different. Because they had the license to the frequency band
they wanted to bring the service further towards the mobile communications.
They thought low-tier service would not be very helpful and thought they
should approach high-tier service. Differing positions began to emerge then.

<div align="right">(Interview with former team leader at Thrunet, 26 May 2011)</div>

Going towards wireless had provided a common thread among the fixed-broadband
carriers, yet *how to* pursue this drew differing concerns: the thread had been linked
to different histories, backgrounds, positions, and visions towards the future.

Although the initial research on the use of the 2.3GHz band had produced a partial
agreement on what the incumbent fixed-broadband carriers regarded as future
wireless service, a consecutive research group was formed in RAPA with additional
participants. This time the research group included not only the fixed-line broadband
carriers but also the mobile operators, public research institute, system vendors, and
academics. The coordinated arena of the 2.3Ghz frequency band thus became at once
a negotiated space where various players, including the fixed broadband carriers,
mobile operators, and system manufacturers were engaged to define their future
wireless-access service, ultimately headed towards fixed-mobile convergence.

In the mean time, the telecommunications market was seen to evolve from circuit-
based voice telephony to IP-based data service, as well as from fixed-line
communications to wireless communications. Furthermore, the evolution was
expected to move towards the convergence between the fixed and the mobile,
thereby enabling high-speed Internet access, unhindered by time and location (MIC,
2001a). Although such a vision was more or less shared among the players, the

challenging task lay in defining the new wireless infrastructure and service to run in the 2.3GHz band. With the leading mobile operator's entrance to the negotiated arena of the 2.3GHz band, the locus of the coordination to solve the problem of inefficient use of the spectrum resource evolved towards further embracing the shaping of the future high-speed wireless-access service, involving players from fixed and mobile communications.

4.1.3. Redefining the wireless : Fixed vs. mobile

The players' visions had been aligned towards the future convergence of fixed and mobile with their approaches yet to be integrated. The key issue lay in redefining *wireless* service of which the existing boundary had been marked clearly between the fixed and the mobile: the wireless LAN and the mobile telephony. Disputes increased, especially with regard to the positioning of the emerging service in relation to the existing services for wireless and mobile access to the Internet. Although the fixed-broadband carriers intended to expand their fixed service boundary by approaching wireless service with added mobility and voice function, exploring how to differentiate the service from the existing mobile service had also been a key issue linked to service conceptualization:

> As the dispute between Wifi and WiBro[13] was being settled (among the fixed broadband carriers) to a certain extent, there was another matter: Wifi would have been clearly differentiated from mobile communications service but if we were to go with WiBro, which service positioning should we have? Then it was said to be datacentric service. But then mobile communications would also provide data service, and how should it be differentiated from mobile data service? It was much disputed. Many gathered to find a solution and then decided to remove the voice service. It would have been the differentiating point from mobile telephony if it did not have the voice function. Another concern was about limiting the moving speed: to what extent should the speed be limited? This was set at 60km/h. It should be usable at least in buses. … The service had to be provided through laptops or

---

[13] "WiBro" in this interview indicates the service which was then a conceptual service proposed by KT and Hanaro.

other data terminals rather than voice, so we concluded it should go with mid-position while being datacentric and that it should support the moving speed of 60km/h.

<div align="right">(Interview with former team leader at Thrunet, 26 May 2011)</div>

The boundary between the fixed and the mobile was disputed, especially with regard to the extent of mobility the service would allow. Although mobility had been one of the major concerns for the fixed-broadband carriers in enhancing their wireless service, it was at the same time unsettling for the mobile operators, since mobility had hitherto been the distinctive feature of mobile services. As the fixed-broadband carriers, especially KT and Hanaro, were approaching the concept of the new wireless-access service to include voice and mobility, South Korea's leading mobile operator, SKT, saw the service increasingly tending to cross the boundary of mobile service. The mobile operator had thus been prompted to participate in the negotiation process towards next-generation wireless service, yet with a motivation that largely differed from that of the fixed-broadband carriers:

> SK Telecom began to participate in the project (discussion) since the government decided that the 2.3GHz wireless arena would form a new service area. At that time it was regarded as being in the middle of fixed and mobile communications. … We could see it as wireless mobile telephony business as well as seeing the fixed wire-line broadband Internet business extended to the wireless business. So it used to be regarded as being between the fixed and mobile as well as fixed-mobile convergence. … At that point, our company concluded that although it evolved from the fixed-line Internet, it is a wireless[14] business, and that it would have a great impact on our company's business. So we participated since then.

<div align="right">(Interview with Director at SKT, 13 September 2010)</div>

In fact, uncertainties in the evolution of wireless services were at once an opportunity and threat to existing players who had been placed in the formerly

---

[14] Although the term "wireless" is now most popularly used for the wireless access services including WiFi, the "wireless" mentioned by interviewees often seemed to mean "mobile communication," differentiated from fixed services.

differentiated wireless field, separated by the boundaries of the fixed and the mobile. Although the fixed-broadband carriers approached the new service as a bridge towards their enhanced future wireless service, the mobile operator was concerned about possible cannibalization[15] of their existing mobile services:

> In fact, from SKT's point of view, … we did participate very actively from the stage of writing up business plans for WiBro, but there was a dispute from the beginning with matters concerning cannibalization. There was an extent of overlap between mobile telephony and WiBro.
>
> (Interview with Director at SKT, 13 September 2010)

Positioning the new service entailed conflicts in the negotiated arena for the 2.3GHz band, especially between fixed-broadband carriers and the mobile operator. The boundaries of what had been firmly separated as fixed and mobile were disputed, redefining the features of *wireless*. The fixed carriers' attempt to expand their service boundary towards wireless prompted the mobile operator's involvement. As to cannibalization, the mobile operator's motivation was seen to include a degree of having to defend and safeguard their own boundaries of existing mobile services, revealed through the issues of voice and speed of mobility to support wireless service.

> If the service positioning had been set as Wifi, it would have had a clear difference, and if the service had stayed with the last -mile solution through the higher power radio device, it could have been resolved among the three fixed-broadband carriers. But KT and Hanaro wanted to go further and insisted on the service positioning mobile data-access service. At that time KTF was separate from KT, and Hanaro also had the intention to acquire some mobile communications service, so they wanted a service closer to high-tier service. And then the mobile operator participated mainly to oppose whatever seemed to cross their service boundary, as they kept monitoring. They opposed certain positioning by arguing it would harm current mobile

---

[15] The *Online Oxford Dictionary* defines "Cannibalize" as "(a company) reducing the sales of (one of its products) by introducing another similar product."

communications. … As such, the speed (wireless supported vehicle speed) was limited, and voice was excluded to go with data-only services and so on.

(Interview with former team leader at Thrunet, 26 May 2011)

The shaping of the concept of emerging wireless service thus involved existing fixed and mobile carriers having to simultaneously exploit and defend what they deemed as opportunities and threats to their present positioning in the face of emerging future wireless service. The emerging 'wireless' service was increasingly blurring the existing boundary between fixed and mobile, whereas the boundary of 'wireless' was being reshaped to encompass fixed-wireless Internet access and cellular data service. At the core of the negotiated arena lay issues linked to differing evolution paths of the 'wireless Internet': the wireless LAN enabled WiFi and other evolving services from the mobile telephony.

Closure was, however, reached as the coordinated arena of the 2.3GHz band spectrum was eventually reframed by regulatory decision. In December 2002, the Ministry of Information and Communication made an official announcement of the change in use of the 2.3GHz spectrum band from previous WLL use. The spectrum band between 2300~2400MHz was reallocated as a band for Portable Internet[16] under Spectrum Law, Article 9.[17] The Portable Internet was formally defined as 'Portable type Internet service that provides high-speed wireless access to Internet anytime and anywhere at standing still or moving state' (MIC, 2002, p6). It was offered as the generic vision shaped through the coordinated yet negotiated arena of the 2.3GHz frequency band. It was a generic vision to be further explored and applied in a diverging and evolving market for telecommunications service.

---

[16]The report further elaborated on the terms and the phrases used in defining the service: 'at standing still or a moving state' meant guaranteeing low-speed mobility covering standing still to a nomadic state, yet providing high-speed mobility when necessary; 'Anytime and anywhere' was defined as providing seamless Internet access not only indoors, including homes and offices, but also outside such as in parks, streets, and roads; Finally 'high-speed' was to denote the data-transfer speed of high-speed fixed-line Internet (1~2Mbps per subscriber), able to support higher speeds when necessary (MIC 2002, 55p).
[17]Ministry of Information and Communication Notification No. 2002-53: Announcement on the change in the Korean Table of Frequency Allocations (14 October, 2002) under Spectrum Law Article 9.

4.1.4. Summary

The process of initiating coordinated efforts to shape WiBro service was constituted by diverse players and their interactions; their aims, objectives, and visions differed to a degree. The coordination of working groups by MIC had been aimed at producing recommendations for efficient use of the spectrum in the 2.3GHz frequency band, and resulted in bringing about a set of recommendations to enhance the efficiency of use. However, participants represented competing visions and diverging interests, yet to be realised into a particular type of commercial telecommunications service. The generic vision of Portable Internet had been reached through the formal establishment of negotiating spaces through RAPA. The generic vision was then relayed to another coordinated space for negotiation of a single standard for Portable Internet service, as required by MIC upon reallocation of the 2.3GHz frequency band.

This section has demonstrated the formation of a coordinated arena, filled with competing visions and diverging interests towards the shaping of an emerging telecommunications service. It discussed how the specific frequency band of spectrum came to be problematised by a fixed-line broadband carrier whose interest had been to expand its business towards advanced wireless broadband Internet service by securing spectrum resources. The problem then resulted in coordination of several consecutive meetings whereby diverging interests negotiated to produce recommendations to support regulatory decisions about reallocation of the spectrum. MIC made the final decision on the reallocation of the 2.3GHz frequency band for Portable Internet use, whereas the concept of the Portable Internet provided a generic vision for next-generation wireless broadband Internet service.

The following section examines additional dynamics that arose in relation to the coordinated activities that resulted in securing the availability of an additional spectrum resource for an emerging telecommunications service.

4.2 The coordinated R&D: The High-speed Portable Internet (HPi)

By the time MIC made an official announcement on the reallocation of the 2.3GHz frequency band for Portable Internet use, the Information and Communication Policy

department[18] at MIC had coordinated an R&D project on Portable Internet through the largest and leading government-funded research institute in telecommunications, ETRI (Korea Electronics and Telecommunications Research Institute). ETRI was a research institute funded by MIC and it had played important roles in initiating new and large-scale telecommunications infrastructures throughout Korean telecommunications history. ETRI had played a key role in developing the digital electronic telephone-switching system, TDX, as well as the digital mobile telecommunications system, CDMA. These were generally regarded as foremost successes that had been achieved through coordinated R&D programmes by the government in the nation's telecommunications history.

ETRI coordinated the national R&D programme for the development of an HPi system as a three-year R&D programme to be undertaken between January 2003 and December 2005. This section discusses the diverging interests and interactions involved in the coordination of the R&D programme, as well as the varying motivations and commitments that shaped the development of Portable Internet. First, it examines the early interactions and motivations that have come to build links between the R&D programme and the 2.3GHz frequency band. Second, it discusses the key motivations and drivers that enabled coordination of a national R&D programme on HPi. Third, it further explores differing goals, priorities, and commitments towards the development of the HPi system.

4.2.1. Encountering the 2.3GHz frequency band

An occasion was recalled by an interviewee where the leading telecommunications research institute, ETRI came to learn about what the fixed-line broadband carriers were envisioning for near future telecommunications service. The interviewee from a network carrier recounted an event in which ETRI invited KT and Thrunet to introduce each of their own visions about the future service to be implemented in the 2.3GHz frequency band:

---

[18] MIC's Information and Communication Policy department (1999-2006) was in charge of the three-year HPi R&D project (2003–2005) whereas spectrum issues were managed by the Spectrum Department at MIC. (Interview, Secretary at Ministry of Knowledge and Economy positioned at MIC prior to the restructuring of the Ministries in 2008)

KT had suggested a service similar to mobile communications whereas Thrunet proposed a WiFi with higher output, namely Public WLAN. As it was difficult to know which of these would be more adequate, ETRI prepared a place where the representative from KT and Thrunet were invited to give a talk on each of the technologies. … The two types of technologies were discussed with the master's and doctorate-level researchers from two departments at ETRI: one was the mobile-communications department and the other was the wireless LAN-related department.

<div align="right">(Interview with former team leader at Thrunet, 26 May 2011)</div>

It was not until 2003 that the technology research teams at ETRI formally participated in the research project on the efficient use of the 2.3GHz frequency band, which had been coordinated through RAPA. This meant the formal negotiation involving the network carriers and ETRI regarding Portable Internet had begun in 2003. However, ETRI had encountered the issue of spectrum reallocation in the 2.3GHz frequency band by 2002 when ETRI had just begun to pursue the research and development regarding fourth-generation mobile communications. ETRI soon found a link between their R&D activities on 4G and the additional spectrum band to be reallocated. An interviewee from ETRI explained their involvement as having been prompted by the reallocation of the 2.3GHz frequency band:

In 2002, we were undertaking research related to 4G mobile communications using OFDM. At that time 2.3GHz band had been allocated for WLL but there were only a small number of subscribers to the service, and then there were requests for resolving (inefficiency). It was the period when ADSL was being widely implemented by fixed-broadband carriers. Then the Director, Mr. Han, suggested we try ADSL in wireless. So the project was planned in 2002 targeting the 2.3Ghz band, and was initiated in 2003.

<div align="right">(Interview with former Director at ETRI, 31 May 2010)</div>

The main motivation for initiating the coordinated ETRI R&D on the HPi system was explained by two key issues: i) There was a rapid increase in the use of the fixed-line broadband Internet and mobile telephony. Domestic fixed-line broadband

Internet users amounted to 25,650,000 (50% of the population as of June 2002) and mobile telephone subscribers were 30,880,000 (65% of population; (Ahn, 2009); ii) Despite increasing demands for mobile-based wireless Internet, there were limits in providing low-cost mobile Internet. Therefore, there was sufficient need to develop an HPi system that would overcome the limits of the existing wireless LAN by having a larger cell radius and would support low- to mid-speed mobility for using the high-speed Internet (Ahn et al., 2003; Song et al., 2003). Portable Internet was thus regarded as a service positioned between wireless LAN and mobile telephony that would eventually overcome the limits of both technological offerings and provide high-speed Internet access at any time and anywhere (Ahn et al., 2003).

ETRI's involvement in the development of a candidate system for Portable Internet also had bearing on technological issues. Although similar types of advanced technologies were being developed by foreign companies intended for high-speed wireless Internet access, none had yet fully entered the telecommunications market and required further technological developments to meet actual market needs:

> Where would it go after W-CDMA. We thought it would be OFDM. In 2002, OFDM-based systems, developed by companies including Flarion, were introduced in Korea, but the systems had limitations, and the telecommunications operators found problems in commercializing them. So our intention was to make improvements from those technologies that were available then.

<div align="right">(Interview with former Director at ETRI, 31 May 2010)</div>

Such recognition of the market needs for Portable Internet as had been envisioned through the reallocation of the 2.3GHz frequency band, as well as the rationale for developing OFDM-based systems were linked to initiate an R&D programme on the development of a candidate technology and system for the Portable Internet.

ETRI had been pursuing research beyond IMT-2000 since early 2002. The vision of Portable Internet that had been shaped through the spectrum arena was then linked to the vision of 4th-generation mobile communications. In 2002, ETRI had planned two R&D paths towards 4G: one leading to what they envisioned as 'low-tier'

technologies to support 'high-speed, low-cost, hot-spot area wireless mobile Internet services' and the other to develop 'high-tier'[19] technologies to support 'high-speed, wide-area wireless mobile Internet services' (Vice President Ki-Chul Han, A Study on Systems Beyond IMT-2000 in Korea, ETRI 28 May 2002). They initiated the High-speed Mobile Internet (HMi) project in 2002 to develop a candidate system for the 'low-tier' 4G. The HMi project was then extended to a three-year national R&D programme on HPi to be carried out during 2003–2005.

HPi thus represented a programme of new opportunity shaped through availability of the spectrum resource in the 2.3GHz frequency band. The following section discusses the merging of multiple interests aligned towards shaping the HPi system, yet based on their differing histories, current needs, and future visions.

4.2.2. Coordinated R&D: towards a 'home-grown' next generation mobile communications

In 2003, a large-scale national R&D programme was launched to be undertaken for three years. It was named the "2.3GHz High-speed Portable Internet System (HPi) Research and Development," led by ETRI and joined by Samsung Electronics, Hanaro Telecom, KT, KTF, and SK Telecom. Participants were the collaborative funding source for the programme. Total funds amounting to 38.5 billion KRW[20] were fully provided by these participating industry players. Samsung was the major investor in the programme and a major player in actual R&D activities, tightly coupled with ETRI: Samsung invested 27 billion KRW with 350 research staff members participating in the collaborative R&D with ETRI (Song et al., 2007). Samsung's leadership in the coordinated R&D was also reflected in an interview with the project's former Director at ETRI :

> The WiBro programme was industry led, and there was much dispute with
> regard to who would take responsibility for managing it (within ETRI). At

---

[19] "High-tier systems feature high-power transmitters, base stations with coverage ranges on the order of kilometers, and subscribers moving at vehicular speeds. Low-tier systems, serving subscribers moving at pedestrian speeds, have low-power transmitters with a range on the order of 100 meters (m)" (Computer Science and Telecommunications Board, National Research Council, 1997 The Evolution of Untethered Communications, 31p)

[20] Approximately 22.8 million GBP (1GBP ≒ 1,700 KRW).

that time, no one had expected it would be very successful; there was much dispute since it was a large scale project, and a joint project with Samsung meant it should directly lead to commercialization. … It was a bit risky at that time so it was much disputed whether or not it was a feasible programme.

<div align="right">(Interview with former Director at ETRI, 31 May 2010)</div>

In fact, coordination of a collaborative R&D between Samsung and ETRI was also built on previous relations and experiences with successful development of telecommunications technologies and systems:

Samsung Electronics was also a collaborator for W-CDMA, which was funded by the government. We had worked with Samsung for a long time, also in the TDX case. It seemed there were not many years that we'd worked without funding from Samsung Electronics. The projects that I was in charge of always had Samsung involved. So I think [the director of the research centre] had thought I could mediate well between Samsung and ETRI."

<div align="right">(Interview with former Director at ETRI, 31 May 2010)</div>

This time, as a leading manufacturer of mobile handsets in the global market, Samsung had the aim of amplifying its present status as a manufacturer developing and producing handsets. Through the development of HPi, Samsung would pursue expanding its business boundary as a mobile-device and equipment vendor in the global market (Radha et al., 2008). Furthermore, Samsung's huge success of developing CDMA(Code-Division Multiple Access) phones had accompanied a critical lesson about the importance of securing intellectual property rights (IPRs) as huge royalty fees were paid to a foreign company, Qualcomm (Song et al., 2007).

Samsung's R&D team for the development of the HPi had thus been given the mission of developing a technological system that would not require huge royalties to be paid to a foreign company. A quotation taken from an interview in Hankyung magazine with the Executive Director of Samsung indicated this mission that was given to him by Samsung's then President, Lee Ki-tae (Jang, 4 September 2006):

Let's do something that we wouldn't need to pay royalties to a foreign

company. Find some way to do this. We will invest as much money as

needed"

(Interview quotation from Hankyung magazine[21] with Samsung Executive

Director)

Such a mission was then aligned with ETRI's vision for developing a 'home-grown' system for a next-generation wireless system. ETRI had aimed to take the lead in securing intellectual property rights for the development of OFDM-related technologies, driven, to an extent, by OFDM-related research being carried out in the United States and Japan (e.g., Flarion's Flash-OFDM, NTT DoCoMo's 100Mbps enabling OFDM based high-speed data transmit technology; (Song et al., 2003).

The two organisations—ETRI and Samsung—had visions and aims once again closely aligned towards developing the new home-grown wireless system and service (Lee et al., 2006). In fact, such a vision had been aligned especially with and promoted by the innovation policy of the Korean government. By the year 2003, MIC had prepared a policy to promote '9 IT New Growth Engines' to advance its IT industry. The key objective for developing next-generation mobile communications had been set for the development of basic and source technology for securing property rights for domestic industry players (Ji et al., 2004). HPi, thus, was included as the key technology promoted through MIC's IT policy, as it was a domestically initiated technology in comparison with other possible candidate technologies for Portable Internet, being developed by foreign companies.

The development of HPi was thus driven by the alignment of visions and aims of the Ministry, ETRI, Samsung, and others. The rationale for the collaborative development of the HPi system included reducing investment fees, reducing unit cost by realising economies of scale, and by reducing the burden of paying royalties (Ahn et al., 2003). Each represented the main interest and aim of participating players whereas each player had a different roles to play in fulfilling their aims and visions.

---

[21] Hankyung Magazine, Business 560 (28 August 2006).

4.2.3. Diverging roles and commitments towards the development of an HPi system

The R&D programme of HPi had thus been initiated, coordinated as an arena where the next generation high-speed wireless Internet access technology was to be shaped through the collaboration of multiple players. From the outset, collective roles were seamlessly allocated to participants. The government, academia, manufacturer, and telecommunications operators each had roles to play that together would fulfill the functions necessary to drive technological innovation. ETRI was responsible for the development of the core technology and experimental system for the HPi system, whereas Samsung's role spanned developing core technology and commercial systems. Operators were expected to identify service requirements while the government's role generally fell into the regulatory arena of spectrum and standards (Ahn, 2009).

The alignment formed through the R&D programme of HPi was only partial in incorporating shared goals and aims towards commercialisation of the technology. Although the generic vision of the Portable Internet had been formed and applied in the shaping of HPi, what was being envisioned through the technological innovation differed to a degree. For ETRI, HPi was regarded as one of the major pathways to build its global competency by taking the technological leadership in the next-generation mobile communications field. For Samsung, the strategy of securing IPRs in core technologies for next-generation communications was further linked to the company's aim to leapfrog from its current position, subject to foreign vendors, as well as to extend their role from handsets to systems manufacturer in the global market.[22]

While Samsung and ETRI's missions and interests had been nonetheless closely tied to each other to form a synergistic alliance in R&D, other participants in the HPi Programme, namely KT, SKT, and Hanaro Telecom had rather differing concerns and interests with regard to the R&D of the HPi system. Although the HPi programme included the major telecommunications operators as cofunding

---

[22] Interview with Director at Samsung Electronics, and Senior research engineer, Samsung Electro-Mechanics.

organisations and participants, their views towards the technology system differed based on their positions in the current market for telecommunications.

Fixed-broadband carriers, including KT and Hanaro Telecom, preferred to adopt currently available systems developed by foreign vendors, as they wished to make a time-to-market strategy to overcome the near-saturated market for fixed-broadband Internet. Although they were jointly venturing on the development of the HPi system, they were, at the same time exploring different types of wireless broadband technologies such as Flarion's flash-OFDM and Broadstorm's i-Burst. Early implementation and commercialisation were the key issues for the fixed-broadband carriers whose intentions were to enter the high-speed wireless data market (Kim, 2003a).

However, SKT, the largest and leading mobile operator, was more laid back with regard to early commercialization of high-speed wireless broadband. As a mobile operator, implementing a high-end innovative technological system was less their concern than securing compatibility with their existing mobile infrastructure. From the mobile operator's perspective, there was still an issue of compatibility unresolved with the HPi system:

> In fact, WiBro (Portable Internet) technology was not compatible with existing mobile telephony. What mobile operators require is that new technologies being developed have compatibility with existing systems and equipment as the technology evolves. This would minimize the investment fee. On the other hand, from the perspective of fixed broadband carriers, while being purported as being between the fixed-line and the wireless, it was in fact crossing the boundary of the wireless arena. So, because they did not own mobile infrastructure, they wanted a technologically superior system without providing compatibility. WiBro (Portable Internet) was in fact in a way born out of the fixed carriers' needs, and that's why it was built upon the most leading, the most high-end technologies.
>
> (Interview with Director at SKT, 13 September 2010)

Rather, faced with issue of compatibility and the evolution of mobile communications, SKT's concern regarding the HPi system was more aligned with the manufacturer and the developer's interests of securing ownership of core technologies for the next-generation communications service by setting an international standard.

> There were technologies that could be viewed as Portable Internet in the first place, such as Flarion's Flash-OFDM and so on. American companies such as Navini owned many technologies. An issue for KT was to commercialise those technologies immediately, while the government and our positions were to secure core technologies by standardising in Korea to drive the world market. In fact, KT had the need to enter the wireless market as soon as possible. But, our company was more inclined towards standardization and the global market, since we already had a firm position in the wireless area.
>
> (Interview with Director at SKT, 13 September 2010)

SKT, thus being aligned with Samsung and ETRI, insisted that the domestic-driven indigenous innovation of HPi should not be hindered by adopting foreign technology systems, and therefore they would wait for the development of home-grown technologies and systems for commercialization (Lee, 2003a).

The development of an HPi system was thus linked to various issues spanning the time-to-market strategy, IPR procurement for next-generation mobile communication, securing global technology leadership and making a seamless transition towards next-generation mobile communications. Differing urgencies were at play for players from different backgrounds and positions, which resulted in not only differing roles but differing degrees of commitment towards the development of the HPi system. Although the players had generally been aligned towards the generic vision of Portable Internet, shaped through the spectrum arena, their alignments towards the HPi system were rather partial in commitment to the future outcomes of the coordinated R&D. In April 2004, HPi was selected as a single baseline technology for setting the standards for Portable Internet. In December 2004, the first trial service using the prototype of a Portable Internet system was carried out by

ETRI and Samsung. By June 2006, commercial systems were deployed at several hotspots for early stage WiBro service.

4.2.4. Summary

This section has discussed the process of varying interests aligned towards the development of an emerging technology through the coordination of an R&D Programme on HPi. The R&D programme was coordinated in conjunction with the shaping of the generic vision of Portable Internet, which took place through reallocation of the 2.3GHz frequency band. Yet, coordination of the R&D programme was not formally linked to the spectrum of the 2.3GHz frequency band from the outset. The players involved in the R&D on the HPi system targeted the 2.3GHz band whereas only one of the candidates would realise Portable Internet service. Although the spectrum arena had been coordinated through RAPA following the interests of the fixed-line carriers to use the 2.3GHz frequency band, the R&D arena was coordinated through ETRI, whose interest was aligned with those of the leading manufacturers and the governments (MIC in particular) towards developing a home-grown technological system.

Under the auspices of MIC, the coordinated R&D programme was led by ETRI in close collaboration with Samsung, whereas further collaboration involved major network operators as participants in the programme. The coordinated arena of R&D thus, in part, represented a seamless alignment of varying interests, driven towards the development of a home-grown technological system, enabled by past relations and experiences that had resulted in successful cases of technological innovation. However, whereas the collaborative R&D resulted in the successful development of commercial Portable Internet system in three years time, this section has further described the differing aims and interests among participants in the coordinated arena.

In the following section, the coordination of a standard-setting arena is discussed. It examines how differing interests and their alignments were further reconfigured through the standardisation of Portable Internet, later renamed WiBro.

Following the reallocation of the spectrum in the 2.3GHz frequency band, the regulatory decision had directed, coordinated by a standard-setting group at the Telecommunications Technology Association (TTA)[23], the organisation for ICT standardisation in South Korea. The single standard for Portable Internet was to be set whereas no specific technology immediately suited the vision of Portable Internet. The generic vision of Portable Internet was thus to be realised through the process of standardisation amongst the technologies that were emerging in the market for wireless broadband systems and service.

This section examines the process from the emergence to the evolution of a coordinated arena aligned with interactions through the process of standardisation of Portable Internet. First, it discusses the emergence of the coordinated arena of the domestic standardisation of Portable Internet: how and for what purpose the project group on standard setting of Portable Internet was formed. Second, the discussion follows the extended relationships in the project group at TTA with a working group of an international-standards-development organisation. Third, it observes how the relations and interactions in the coordinated arena evolved through the process of 'globalisation' of the Portable Internet standard. It also reflects on the changes in the meaning of a home-grown technology in relation to globalisation.

4.3.1. The coordinated arena of standardisation

The regulatory decision to reallocate the spectrum in the 2.3GHz frequency band was accompanied by a decision to follow a single standard approach to commercial Portable Internet service in South Korea. The decision on the single-standard setting for Portable Internet was decided in a meeting organised by the Director of Spectrum and Broadcasting Planning Department, Ministry of Information and Communication in October 2002 (Kim 2007). The decision stated that a single standard for Portable Internet would be selected through TTA of Korea, whose main role included planning, establishing, and distributing ICT standards in close

---

[23] Telecommunications Technology Association (TTA) of Korea is an organization for standardizing cooperative group standards in electronics and information and communications (ICTs). TTA was established in December 1988 to promote private-led standardisation related to electric-communications.

cooperation with companies, organizations, and others concerned with information and communications[24] (MIC, 2004a). Therefore, among the candidate Portable Internet systems that were competing in the market for early commercial deployment, the choice was to be made through the standard setting of the Portable Internet.

In the six months since MIC had announced the reallocation of the 2.3GHz frequency band for Portable Internet use, the Project Group for Portable Internet (PG05)[25] was inaugurated in TTA. The Radio and Broadcasting Bureau at MIC was responsible for overseeing the process of standardisation whereas standard setting was coordinated through TTA. The Radio and Broadcasting Bureau was in charge of managing spectrum resources, visions, and missions that had been shaped through the spectrum arena, then extended to guide the standard setting of Portable Internet. The generic vision of Portable Internet was thus rephrased in the standardisation arena as service providing 'high data rate wireless Internet access with Personal Subscriber Station (PSS) under the stationary or mobile environment, anytime and anywhere' (Hong et al., 2004b). The general requirements for Portable Internet standards were further identified as follows: i) enable high-speed Internet use indoors and outside at the data-transfer speed of fixed-line Internet; ii) maximize the efficiency of the allocated spectrum use; iii) minimize the fees (e.g., for network implementation) and end-user price; iv) minimize the burden of IPR-related fees; v) enable time-to-market introduction and support adequate mobility and hand-off capability (Hong et al., 2004a).

The alignment of varying interests, which had been initiated through the coordination of the spectrum arena for the reallocation of the 2.3GHz frequency band, were further extended to include much more diverse players towards standardisation. The fixed-line, wireless and mobile-communications-related vendors, operators, and service providers, as well as academic and research institutes, came to participate in the standard-setting process. At the inaugural meeting, 253 individuals participated from 52 organisations including manufacturers, developers,

---

[24]'Policy Scheme for 2.3GHz band Spectrum Use' <October, 2002> quoted from 'WiBro Licensing Policy Scheme'.
[25] PG05 was later changed to PG302 due to a change in organizational structure.

network operators, service providers and academics, marking the largest and the widest ever participation in the domestic standardisation in telecommunications history (TTA, 2008a).

Table 4 Basic frame of Standard Setting of Portable Internet

Service definition	- Portable Internet service enabling high data rate wireless Internet access under stationary or mobile environment, anytime and anywhere
Objective of standardisation	- Secure technology and service which are of high marketability and competitive. Seek global standardisation.
Methods and procedures	- Parallel use of top-down method and business verification, standardisation
Scope of standardisation	- Agreed upon achieving a single national standard (June 2004)
International standardisation	- Drive international standardisation
Intellectual Property Rights	- Secure technology leadership through the development of proprietary technology, and minimise royalty

(2008 Information and Communication Standardisation Handbook Appendix)

Although the vision of a Portable Internet standard was closely linked with the vision shaped through the spectrum arena, the technical specifications for the Portable Internet standard had yet to be defined. In fact, various choices and preferences for Portable Internet standards were only emerging in the domestic market following the reallocation of the 2.3GHz frequency band for Portable Internet use. A wide array of technologies were being promoted market players as candidates for a Portable Internet standard, including Ripwave by Navini, i-Burst by ArrayComm, flash-OFDM by Flarion and BroadAir by BroadStorm. Some were at the verge of entering the market, and others were being developed for commercial implementation. HPi was also one of the candidates while it was being developed by a consortium of Korean players: ETRI, Samsung, KT, Hanaro Telecom, KTF and SKT (MIC, 2003).

Along with initiation of the standardisation on Portable Internet, a number of sites were coming together to bring the candidate technologies to near commercialisable products. The network operators, developers, and manufacturers of technologies actively collaborated in implementing several test beds, as well as perform demonstrations and field tests. KT built test beds with i-Burst (ArrayComm), flash-OFDM (Flarion), Ripwave (Navini) and BroadAir (Broadstorm) (Chung, 11

December 2003). Hanaro Telecom also actively sought wireless broadband technology to pursue adoption by testing and demonstrating flash-OFDM, BroadAir, and Ripwave (Song, 20 May 2003). SKT, the leading operator, held several performance tests with related technologies, especially focusing on the functions of handover and access rates. Meanwhile, LG Electronics, one of the leading manufacturers in Korea, was developing an i-Burst-based system aiming for commercial production by 2004 (KOIC, 5 January 2004). Emerging as candidates for Portable Internet service, however, the technologies were to compete through the process of standardisation to become the single standard for Portable Internet service in Korea.

However, another approach to the standard setting of Portable Internet was a 'top-down' approach. Due to the tight schedule that had been allocated for the standardisation of Portable Internet, the standard setting would employ the top-down approach by first deciding on key technologies, parameters, and requirements for wireless access. Then, through the bottom-up process of application of candidate technologies that met the requirements, a baseline specification for Portable Internet would be selected through a technical-evaluation process (Hong et al., 2004b). During the process of setting requirements as a top-down approach, discussions and debates were held in the Radio Access working group in PG05 aimed at defining the required system parameters and radio-access requirements for domestic Portable Internet service. The final decision was to be brought through agreements among the participants. The Time-Division Duplex (TDD)[26] type of duplexing scheme was chosen by agreement, as it was commonly considered to enhance the efficiency of spectrum use. Issues related to radio-access requirements such as the frequency-reuse factor, mobility speed, service coverage, and spectral efficiency were generally agreed upon by participating members of PG05. However, regarding multiple access and channel bandwidth, further disputes and disagreements arose among the industry

---

[26]TDD(Time Division Duplex) is a duplexing scheme that requires one channel for transmitting downlink and uplink sub-frames at two distinct times lots. TDD therefore has higher spectral efficiency than another duplexing scheme, FDD (Frequency Division Duplex). FDD is commonly used in cellular networks as it occupies a symmetric downlink and uplink channel pair which makes it suitable for bi-directional voice service. (http://www.conniq.com/WiMAX/tdd-fdd.htm)

members, as various organizations had different opinions about the choices for a multiple-access scheme including OFDMA[27], and 5MHz and 10MHz for the channel bandwidth. After delays in the decision-making process, the choice was finally put on vote, where 49 industry members had one vote each (Back, 2004).

However, the disputes were also seen by many as competition between foreign technologies and HPi technology, which was mainly being developed by Samsung and ETRI as a home-grown technology for Portable Internet (Ahn, 2004; Chung, 2003b). In fact, HPi was being built on OFDMA using 10MHz channel bandwidth, whereas additional solutions using MC-TDMA and MC-STDMA as well as 5MHz channel bandwidth were supported by foreign companies including Flarion and ArrayComm. The choice was finally made by vote, choosing OFDMA for multiple access and 10MHz as the channel bandwidth. The result of producing system parameters and radio-access requirements for selecting the baseline technology was thus regarded by many as HPi having been selected over the foreign technologies (Choi, 15 January 2004; Kim, 3 February 2004).

Table 5 Major System Parameters and Radio Access Requirements (as of 31 Jan 2004)[28]

System parameters	Duplexing	TDD
	Multiple Access	OFDMA
	Channel BW	10 [MHz]
Radio Access Requirement	Frequency Reuse Factor	1
	Mobility	=60 [Km/h]
	Service Coverage	=1 [Km]
	Spectral Efficiency [bps/Hz/cell(sector)]	Max. DL / UL = 6/2 Aver. DL / UL = 2/1
	Handoff	=150[ms]
	Throughput (per user)	Max. DL/UL = 3/1[Mbps] Min. DL/UL = 512/128[Kbps]

---

[27] Orthogonal Frequency-Division Multiple Access (OFDMA) is a cellular air interface based on OFDMA for multiple simultaneous users which assigns each user a subset of OFDM subcarriers. (http://encyclopedia2.thefreedictionary.com/OFDMA)
[28]Hong, D. H., C. G. Kang, and Y. S. Cho, 2004a, Current Progress of Portable Internet Standardisation Information and Communication (in Korean), v. 21.

Following TTA's top-down approach to set the system and radio-access requirements, three candidate technologies remained for the selection of the baseline technology: HPi, developed by Samsung and ETRI; another by POSDATA (in collaboration with Wellbell technologies); and one submitted by Orthotron (in collaboration with Netford). The large field of competition among the varying technologies, including those developed by foreign companies, had been reduced to involving three Korean vendors (Song, 30 March 2004). In May 2004, the assessment of three candidates by TTA finally resulted in the selection of HPi, submitted by Samsung and ETRI as the baseline technology for the standard setting of Portable Internet.

The process of domestic standardisation of Portable Internet that resulted in selecting HPi as the baseline technology, however, caused a degree of dispute and complaint among the foreign companies that had attempted to enter the Korean market for Portable Internet. U.S. companies in particular, such as Navini, Flarion, and Arraycomm, raised the issue with the U.S. government regarding the exclusion of their technologies from the Korean market. The issue was conveyed to the Office of the United States Trade Representative (USTR) whose response brought the following statement:

> Several U.S. suppliers are interested in supplying equipment for 2.3.GHz services, but it appears that the standards process, under the influence of the government-funded research institute ETRI, is being manipulated to exclude foreign technologies and promote a technology developed by a particular Korean company. USTR will closely monitor developments in both these areas to ensure that Korea's practices do not run afoul of its trade obligations.
>
> (USTR, 2004, p5)

In summary, the coordinated arena of standardisation of Portable Internet was thus filled with alignments, competition, conflict, and dispute. The coordination of a standard-setting group for Portable Internet had initially brought together varying interests towards the standardisation of Portable Internet, of which the generic vision had been shaped through the spectrum arena. Yet, the process leading to choosing a

single standard resulted in confining the alignment to be built around a single standard technology: HPi. This caused disputes with regard to choosing a domestic technology while excluding foreign technologies. Although the decision had been reached through a formal process of standardisation in the standard-setting group at TTA, the dispute was not resolved in the process of domestic standardisation. It was further brought to an international-level dispute by foreign vendors that had been involved in developing and producing near commercial Portable Internet systems.

However, the story of the standardisation of Portable Internet does not lead to a discussion of conflicts between domestic and international fora. In fact, the coordination arena of standardisation of Portable Internet centered on the vision of "globalisation." The globalisation of the domestic standard was the key mission defined from the outset by the standards group at TTA.

The following section discusses how the coordinated arena of domestic standard setting of Portable Internet was further extended to involve and merge with international innovation players. It further examines how the extended alignments reshaped or reconfigured the coordinated arena of domestic standardisation of Portable Internet.

4.3.2. Extended alignments: From domestic to global standardisation

Among the initial motivations that had led to the standardisation of Portable Internet, however, a key mission was set by the standards group at TTA: globalisation. The goal of the standardisation of Portable Internet at TTA had been set at developing marketable and competitive technology and service, while pursuing global standard setting (Hong et al., 2004b). The standard setting of Portable Internet targeted the domestic market and the global market while pursuing an unprecedented attempt to develop a national standard before the existence of an international standard. The former chair of the Project Group for Portable Internet at TTA expressed the strong desire for globalisation in an interview:

> In the Portable Internet project, 235 people from 52 organisations participated. It targeted the world's leading technology, and research institutes, industry, and universities collaborated for the first time. It was

thought that the technology must be standardised as the domestic market was small. The intention was to have a successful market introduction in Korea and then succeed in the global markets. We had been always using an international standard, but this was the first time that a national standard was to be set when there wasn't even an international standard.

(Interview with Former Chair of Working Group at TTA, 15 October 2009)

The initiative of setting the standard for Portable Internet had been linked to the vision of leapfrogging from a standard user to a standard setter. Also, it aimed to bring the market for Portable Internet beyond the national boundaries (Song et al., 2007). To this aim, the domestic development and implementation of the Portable Internet standard was regarded as a prerequisite to achieve the goal of globalisation of Portable Internet service. Also, the aim was closely linked to securing IPRs and integrating them into the standards[29]. Thus, an IPR Ad hoc Group was established in PG05 to oversee issues related to IPRs, promoting and regulating IPRs related to the standardisation (Lee, 2004a). Regarding the aims of securing IPRs along with pursuing the global standard, the following comment by an interviewee reflected the significance of IPRs that was drawn to the standard-setting process:

The aim of the project was to secure 20% of IPR. In the case of CDMA we had to pay vast amounts of royalty to Qualcomm, and our intention here was to secure cross-licensing, so we would not have to spend too much on the royalties. Not to pay the royalty rather than earning from royalties was our objective.

(Interview with Former Chair of Working Group at TTA, 15 October 2009)

Royalty-related issues had been under serious debate, not only in the industry but also among the wider public and at the level of government innovation policy since the wide penetration of CDMA phones in Korea and beyond. Despite the successful development of CDMA systems and handsets, commercialisation and subsequent diffusion had brought out the issue of huge royalty payments to a foreign company:

---

[29] A study on the relationship between standards and intellectual property rights (IPRs) can be found in Blind et al. (2009). A study on the Interplay between standards and intellectual property rights (IPRs) is the Final Report by the Fraunhofer Institute.

Qualcomm (Kang et al., 2009). Therefore, the objective of globalisation through the standardisation of Portable Internet was closely linked to activities aimed at reflecting and securing IPRs in the global standards. This aim was especially pursued by Samsung, which had also been involved in the development of the HPi system with ETRI. Meanwhile, Samsung's role in linking the domestic standard to a global standard seemed to have been crucial:

> From the beginning, the global market was the goal. If it was just a national standard, companies like Samsung would not have been interested. … Samsung first contacted the international telecommunications operators to whom Samsung had been selling the mobile handsets. Then the telecommunications operators introduced Intel. At that time Intel was carrying out the development and the standardisation of WiMAX technology as the next generation for WLAN.
>
> (Interview with Former Chair of Working Group at TTA, 15 October 2009)

Samsung's efforts to promote the development and implementation of their HPi system in the global market had led to approaching the major global network operators and WiMAX developer Intel. Samsung reaching out for international collaboration had begun with the development of the HPi system through the R&D programme, which eventually brought Samsung and Intel to collaborate on the standard setting of WiMAX technologies, developed through IEEE802.16 standards (Song et al., 2006). Samsung's collaboration with Intel and its subsequent involvement in the development of IEEE802.16 standards was thus regarded as a major opportunity to project domestic IPRs to a global standard (Kim, 2004d). In February 2004, a formal agreement was made regarding the collaboration between Samsung and Intel's development of HPi system and 802.16 standards.

In parallel, yet in relation to the efforts of Samsung in building industry-level alliances, TTA, the domestic standard-setting organisation, sought to build a relationship with global standard-setting bodies. Although TTA had been monitoring and participating in several standard-setting groups including IEEE 802.16 and IEEE 802.20, preference for technical specifications of Portable Internet in TTA had

gradually given more weight to IEEE 802.16 group activities (Choi, 2003a). Following the decision to align the standard-setting activities of PG05 of TTA with those of IEEE802.16, communications about the collaboration were carried out through formal letters between the groups. In January 2004, the International Coordination Ad Hoc group at TTA sent a formal letter to the IEEE 802.16 group aiming at "future possible collaboration" stating that "[r]ecognizing the mutual interests between our two organizations, we propose to begin dialogue for possible discussion and collaboration" (TTA PG05, Liaison letter to IEEE, 12 January, 2004) (Lee, 2004b). In response to TTA's letter, IEEE 802.16 responded by noting they hoped for "compatibility between IEEE 802.16 standards and any overlapping regional standards" and suggested a document exchange for review and comments (IEEE 802.16, Letter to TTA on 26 January 2004)(Marks, 2004a).

On 20 May 2004, after several letter and document exchanges, as well as a face-to-face meeting of the people in charge from both groups, the IEEE 802.16 Working Group proposed "the goal of reaching full alignment between TTA PG302 standards and a subset of the IEEE 802.16 standards, including the future 802.16e amendment" (Liaison letter from IEEE802.16 WG to TTA on 20 May 2004)(Marks, 2004b). TTA PG302 and IEEE 802.16 standards finally entered into a process of harmonization resulting in the revisions of each of the established standards and further harmonization efforts during the evolution of each standard (Joo and Son, 2006; Kim, 2007; Song et al., 2006).

The coordinated arena of the domestic standardisation of Portable Internet was thus reshaped through extended alignment with international innovation players and eventually the international standard-setting arena. In line with the globalisation of Portable Internet, MIC renamed Portable Internet WiBro (Wireless Broadband) in April 2004 (2008 Information and Communication Standardisation Handbook Appendix). MIC further included WiBro as one of the core "new growth engines" that MIC had defined as key innovation areas in its innovation policy. The alignment and harmonisation of TTA PG302 and IEEE802.16 further brought closure to the dispute that had been raised through USTR on possible exclusion of foreign technologies. In the process of resolving disputes and harmonising with an

international standard, WiBro was officially redefined as conforming to the
IEEE802.16 standard with five additional requirements, set as mandatory
requirements by TTA. The name for the TTA PG302 standard, WiBro, was also
limited for use as the name for the service in the domestic market of South Korea
(Kim, 2007).

4.3.3. Shifting alignments towards the evolution of standards

The process of harmonisation of the two initially separate standards, TTA PG302
and IEEE802.16, further led to often shifting relations and interactions among the
innovation players in the coordinated arena of the domestic standard setting of
WiBro. Although integration of certain technical issues involved achieving
agreements at the organisation level between the two standard-setting groups,[30]
participation of the members of TTA in the standard-setting process in IEEE
gradually blurred the boundary between the TTA PG302 standard and the
IEEE802.16 standard.

Many industry and organisational members of TTA, including Samsung Electronics,
LG, ETRI, KT, SKT, and Hanaro Telecom, actively participated in the IEEE802.16
standard-setting process through individual participation as members of the working
group.[31] Their participation as individuals in the standard setting of IEEE802.16
indeed brought a shift in their former relations in the standards group at TTA. At
certain times, one could also sense rising conflicts between Samsung and ETRI, the
two major collaborators for the development of the HPi system, in the process of
standard setting at IEEE:

> Tens of people (from Samsung) participated (in IEEE). ETRI also, for the
> same purpose. … We went there and collaborated a lot. In the beginning

---

[30] e.g., IEEE802.16 had chosen OFDM for the multiplexing scheme whereas TTA PG302
was built on OFDMA as a multiuser version of OFDM. The protocol for mobile broadband
wireless access was agreed to be OFDMA for improved multipath performance in non-line-
of-sight environments, after going through in-depth technical evaluations on OFDM and
OFDMA between the two groups.
Song, J.-y., P.-y. Joo, and Y.-k. Kim, 2006, Process toward the making of WiBro-
International standard: TTA Journal, v. 103, p. 191-194.
[31] In IEEE802.16 Session #35 and #36, the rate of TTA participants in IEEE802.16 was over
25%. (Son et al_IEEE802.16)

there were also some conflicts. It was complicated because if the technical solutions prepared by Samsung were different from ours, then how are we to manage this. There is Samsung's proposal and do we have to oppose to it or cooperate? Likewise, our proposals were different from Samsung's. There were conflicts and tensions because of them.

(Interview with former Director at ETRI, 31 May 2010)

There were also shifts in the mode of setting standards at TTA PG302 in relation to the standard setting at IEEE. Although the standards had been harmonised, members still participated in two separate standard-setting processes: one at the domestic level, the other at the international level. Yet, gradual changes were brought to standard setting between the two separate standards groups. An interviewee reflected on this process:

At some point, domestic standardization was getting delayed. It went the opposite way. At first, the domestic standard was set, but then it became different from IEEE. If it's different, it doesn't fit in the global standard. Were we going to change to the global standard or our standard. Mostly we changed ours. Later, why do it twice. Let's go to IEEE first. We face it and standardise it, and if it gets adopted we reflect it as the domestic standard. In the beginning, the TTA standard was set first, and if there were any changes in the IEEE standard, we made modifications mostly. At a later stage, we went to IEEE first, made proposals there, and if they get confirmed we reflected it on the domestic standard. Actually, the internal process has been very complex. Regarding the problem of going the best possible way, depending on the situations. … In the actual process, situations kept changing. So we had to keep changing directions.

(Interview with former Director at ETRI, 31 May 2010)

The process of harmonisation of the standards between WiBro (TTA PG302) and Mobile WiMAX (IEEE802.16) thus resulted in gradual changes in the process of domestic standardisation. Domestic standard setting was no longer confined to the

interactions among domestic innovation players but was being shaped as a result of extended alignments and interactions of innovation players in the international fora.

Furthermore, the coordinated arena of standardisation of WiBro was then linked to multiple layers of standard-setting processes involving two additional standardisation processes: WiMAX Forum and International Telecommunication Union (ITU). WiMAX Forum had the role of certifying and promoting the compatibility and interoperability of products, based on the IEEE 802.16 standard[32]. Standard setting at the level of ITU was initiated as the IEEE802.16 Working Group submitted a proposal to ITU regarding the inclusion of its mobile WiMAX Release-1 profile, designated IP-OFDMA[33] in the IMT-2000[34] family of standards. Thus, WiMAX Forum was further involved in the role of supporting the inclusion of IEEE802.16e-based Mobile WiMAX[35] in the IMT family of radio-interface technologies.[36] The proposed technology that had been derived from the IEEE802.16 standard was finally and formally recognised as the sixth terrestrial IMT-2000 radio interface by the ITU Radio communication Assembly (RA-07) in October 2007,[37] named OFDMA TDD WMAN.

The Korean system manufacturers, network operators, and others actively participated in these multiple fora of related standard-setting processes, yet not in a monotonous way. Each played a role with differing priorities, goals, and commitments to different processes of standard setting. For example, securing IPRs in the set of global standards was one of the greatest concerns of the manufacturers in relation to international standardisation, whereas network operators' key objectives related to reaching the interoperability of standards, conveyed by an interviewee from SKT, the largest mobile network operator in Korea:

---

[32] http://www.wimaxforum.org/about

[33] IP-OFDMA as consistent with the mobile WiMAX Release -1 profile, specifying TDD with 5 and 10 MHz channel bandwidths. IP-OFDMA was later renamed as "OFDMA TDD WMAN" (http://www.ieee802.org/16/liaison/itu/ip-ofdma/)

[34] http://www.itu.int/md/R03-WP8F-C-1065/en

[35] Mobile WiMAX is based on the IEEE 802.16e-2005 amendment to the previous.

[36] http://www.wimaxforum.org/technology/downloads/WiMAX_and_IMT_2000.pdf

[37] "ITU defines the future of mobile communications: ITU Radio communication Assembly approves new developments for its 3G standards" http://www.itu.int/newsroom/press_releases/2007/30.html

Taking part in standard-setting activities at various standards-development organizations is in fact quite important. … Actual benefits of standardisation accrue to manufacturers, especially those that hold intellectual properties. … They are interested in how much of their contributions are reflected in the standards. … Activities in organisations such as IEEE and 3GPP are indeed very important for the manufacturers, as the specifications are discussed and selected in those groups. … TTA is the organization of national standards so all the (domestic) industry should participate. Yet, the current status of TTA seems a bit formal as an actual standard is being developed in IEEE … and then reflected in TTA. WiMAX Forum is also important, especially for network operators. WiMAX Forum is important because the operators gathered at the WiMAX Forum and decided which of the developed options through IEEE should be commercialised. The Forum also provides certifications on commercial products … so WiMAX Forum became very important for network operators.

(Interview with Director at SKT, 13 September 2010)

Yet, there was the resounding vision of home-grown technology still operating at the level of standardisation at ITU where the nation state was given membership[38] to participate in the process of standard setting. From the perspective of the Korean government, the inclusion of IEEE802.16 standard-based technology (WiBro included technology) in the IMT-2000 family of radio-interface standards was regarded as the foremost opportunity to gain and secure the nation's technology leadership in next-generation communications. The Korean government, as a member-state participant of ITU, was thus deeply involved in the process of standardising as well as coordinating the efforts of national innovation players in setting the sixth technology standard for IMT-2000.

In August 2007, the ITU-R WP8F Special Meeting was held in Seoul, hosted by MIC and organized by TTA, aimed at drawing international consensus for inclusion

---

[38] ITU membership is categorized by Member States, Sector Members, Associates and Academics. The Member States consisted of the Ministries and Administrations that represented the participating nations.

of Mobile-WiMAX in the ITU-R M.1457 Recommendation on IMT-2000 family of standards.[39] WiBro was demonstrated, showcasing the world's first commercialized Mobile WiMAX, which provided various functions of the technology, conforming to the requirements of IMT-2000 standards. When the OFDMA TDD WMAN was finally recognized as the sixth IMT 2000 standard, it was praised and greeted as one of the nation's greatest achievements in its telecommunications history, paving the way for the nation to take leadership in the development and worldwide diffusion of WiBro (Mobile WiMAX). Also, the evolution of Mobile WiMAX was further expected to open the opportunity to secure leadership towards the 4G standard (Joo, 2007a).

The visions, relationships, and alignments of the innovation players had indeed shifted along the varying levels of standardisation, whereas their shifting relations and interactions were simultaneously rooted in the collaborative efforts of the innovation players in the coordinated arena of standardisation at TTA. However, the coordinated arena of domestic standard setting had evolved and was evolving in relation to the diverging interactions that were led through the processes of international standard setting, which were related to a particular specification of a technology being regarded as a home-grown standard. Along the landscape of evolving networks of telecommunications technologies and services, the vision and meaning of home-grown technology were also evolving. In fact, the term had increasingly become contextual along the history of telecommunications in Korea, conveyed through an interviewee's explanation of WiBro as a home-grown technology:

> The TDX: … Our intention was to develop a 'made in Korea' TDX system. The switching system at that time was very expensive:200 to 300 USD per line. We aimed at cost reduction: through domestication. TDX was the case where we developed a made-in-Korea system product based on foreign technologies. In the CDMA case, … there was much dispute with regard to using the well known technology GSM or CDMA. … Many people said CDMA was 3G not 2G. Qualcomm then entered. … But Qualcomm had only

---

[39]http://www.wibro.or.kr/new/news01Read.jsp?nowPage=1&news_num=1

wireless technology, not technology for a switching system. So, we integrated our switching technology with Qualcomm's wireless technology and successfully developed the base station and the base-station controller. It can be viewed that we adopted Qualcomm's wireless technology and then completed it by adding our own system technology—base station and base-station controller—as well as our own MSC (mobile switching center) technology. So, it was in part adopted and in part we used our own technology. But in this case of OFDM-based WiBro, there was no technology transfer through a foreign contract. We wrote the specifications ourselves from the beginning to the end, although we of course made reference to the specifications developed by 16 (IEEE802.16); at least we didn't pay for royalties (as before). We participated in the global standard-setting process, and developed the system in accordance with the international frame, and we reflected the technologies that we developed in addition to them. So, in the respect that we developed systems by competing for technologies in the field of global standard, it could be said it was home-grown. Now there is nothing that can be done individually. Could it become a global standard if done individually? It would only become a domestic standard. It should be understood in this respect. I've added the story of TDX and CDMA as I thought it would be easier to understand if compared it with those cases.

(Interview with former Director at ETRI, 31 May 2010)

The vision of home-grown technology indeed evolved along the process of the standardisation, which had been initiated as a domestic standard setting of an emerging telecommunications technology, yet merged with and evolved as an international standard. Having been recognized as the Profile 1A[40], the significance

---

[40]WiBro has been recognized as Mobile WiMAX Profile 1A. In October 2005 WiMAX Forum published a WiMAX Forum Backgrounder clarifying the WiBro/Mobile WiMAX issue under the title 'The Relationship Between WiBro and Mobile WiMAX'. The document states that 'WiBro is the service name for Mobile WiMAX in Korea' as was publicly announced by the MIC on 29 July 2004, and that it 'uses the same standards, system and certification profiles and certification processes as Mobile WiMAX'. Among the multiple certification profiles designated by the WiMAX Forum, WiBro meets all the requirements of one of the designated Mobile WiMAX certification profiles using TDD and occupying 8.75MHz of the spectrum on the 2.3GHz frequency band. (WiMAX-Forum, 2006, The

of WiBro was seen from a developer's point of view to lie on the degree of autonomy that the manufacturer had achieved, especially with regard to being able to configure the technology:

> It is not a 'bought' technology any more, and we could take pride in ourselves for developing the system product based on our own developed technology. Not only the manufacturing but also by securing IPRs we could have the technology leadership. This enables optimization at the cross-layer parts of Mobile WiMAX, being able to work beyond the mixing and matching of components.
>
> (Interview with Senior Research Engineer of Mobile WiMAX in Samsung, 29 September 2009)

Indeed, the meaning of developing home-grown technology had, to an extent, moved away from stressing the development of a self-sufficient technological system for use inside the boundaries of the nation state. It evolved towards meaning a degree of autonomy in configuring the technology for national use while pursuing collaboration as well as competition in the global market.

4.3.4. Summary

The coordinated arena of standardisation of Portable Internet emerged in response to a regulatory decision, whereas it evolved through shifting relations and interactions in the course of bringing the domestic standard towards globalisation. Although coordinated, it was not an arena driven by static objectives and aims towards the realisation of the generic vision of Portable Internet. The objectives and aims of the individual players were further shaped along the process of interactions and building relations involving diverging players.

This section has thus observed how a coordinated arena of standardisation of Portable Internet emerged in relation to other emergent arenas to shape the next-generation wireless Internet technology and service in South Korea. Further, it

---

Relationship Between WiBro and Mobile WiMAX, *in*
http://www.wimaxforum.org/news/WiBro_and_Mobile_WiMAX_Backgrounder.pdf, ed.

examined how the players in the coordinated arena came to extend alignment with global players. It then discussed how the coordinated arena was reshaped and reconfigured in evolving relations and interactions in the course of building alignment with global players and standard-setting bodies.

4.4 Conclusion

The birth of WiBro as system technology, standard, and service involved complex interactions of building alignment, competition, and conflict among diverse interests. At the same time, these interactions emerged through coordination of alignment towards shaping the generic vision of Portable Internet, initiated by consideration of the reallocation of the spectrum resource in the 2.3GHz frequency band.

In this chapter, coordinated alignments were regarded as representing coordinated arenas of interaction through which the dynamics of shaping relations and interactions were observed. The initial alignments, brought together through coordination often based on regulatory means or policy structures, were further scrutinised to examine the complex interactions that resulted in the emergence and the coevolution of the arenas.

First, it examined how the diverse interests came to be aligned to shape use of the spectrum resource in the 2.3GHz frequency band. Although alignments were coordinated through the government decision upon reconsidering the use of the spectrum band, the arena was filled with competing visions and conflicting aims of diverse interests towards the shaping of spectrum use in the 2.3GHz frequency band. The generic vision of Portable Internet was, however, shaped through these interactions in the arena, reaching closure through the regulatory decision upon reallocation of the spectrum band. Further specification of the generic vision of Portable Internet was to be defined and shaped through the process of standard setting at TTA, the organisation for the standardisation of ICTs.

Second, it discussed how coordination of the R&D programme emerged, linked with the availability of the new spectrum space in the 2.3GHz frequency band. Multiple interests were aligned towards the development of a home-grown next-generation wireless broadband system, the HPi. Yet, among the aligned interests, differing roles and commitments to the development of the HPi system were driven based on organizations' histories, current needs, and future expectations and goals.

Third, it further observed and explicated the process of coordination of a domestic standard-setting process as well as its evolution towards globalisation. The Project Group for standard setting of Portable Internet was coordinated following the regulatory decision made in relation to the reallocation of the spectrum in the 2.3GHz frequency band. The visions and objectives were closely linked to those of the spectrum arena, whereas the process of standardisation led to the choice of specification of HPi as the baseline of the Portable Internet standard. The vision of globalisation of the Portable Internet standard was thus linked to the vision of developing home-grown technology, which together evolved to envision reflecting and securing IPRs owned by national players in the standards being developed in the international fora. In the process of merging interests and extending alignment towards globalisation, the relations and alignments in the coordinated arena of domestic standard setting shifted and were reconfigured in relation to evolving relationships and interactions in global standard-setting processes.

This chapter has therefore explicated the dynamic interactions among the diverse array of innovation players involved in the coordination of, as well as the coevolution of the emergent arenas of spectrum, technology R&D, and standard. Although the coordination of alignments towards particular aims and visions played a key role in initiating, mediating, and promoting interactions, the process of coordination and its further evolution were shaped by complex interactions involving varying levels of alignments: alignments involving multiple players towards a generic vision, alignments between technological developers and system manufacturers, alignments between fixed-line broadband carriers, alignments between domestic and international players, and many more. These alignments were accompanied by competition, conflict, and shifting relationships that brought about

the reshaping and coevolution of the coordinated arenas, further driven towards spectrum licensing, the development of HPi system, and the global standardisation towards the commercialisation of WiBro and Mobile WiMAX.

Chapter 5 From alignments to divergence: Towards commercialisation of WiBro

5.0 Introduction

This chapter extends the story of the technological development and the standardisation of WiBro in the commercial uptake. The interactions that constitute the process of commercialisation discussed here do not begin where the process of technological development ends. Rather, the interactions involved in the commercialisation of the emerging telecommunications service took place concurrently with the processes involving coordination of alignments towards the shaping of the generic visions of WiBro through the spectrum allocation, R&D, and standards setting. This chapter demonstrates the differing dynamics that occur in relation to coordinated alignment: the complex interplays among the diverse arrays of interests involved in a 'multilevel game,' where particular participants carry 'certain more or less covert goals, which [are] not necessarily shared' while having the 'formally stated shared goals' (Williams et al., 2005, 87p). Furthermore, the concept of *appropriation* from the social-learning framework has been applied in delineating the processes leading to adapting the generic vision, technology, and standard of WiBro to specific local contexts and use (van Lieshout et al., 2001; Williams et al., 2000; Williams et al., 2005).

In the first section, I observe the emergence of alignments upon allocation of the 2.3GHz frequency band for Portable Internet use, which are then reconfigured in response to the standard setting of the Portable Internet. Yet, the reconfiguration of alignments through standardisation did not lead to a coherent interplay of interests in the deployment of the single standard of Portable Internet. Upon players' pursuit of spectrum licenses, diverging visions were competitively projected by the players with regard to strategies of appropriating the spectrum resource and the single standard, along with the generic vision of WiBro, for the commercial deployment of an emerging telecommunications service.

In the second section, I further examine the divergence and discrepancies that arose in the course of appropriating the generic capabilities of WiBro into specific services

by the players involved in the process of commercialisation. I highlight the differing urgencies between the manufacturer and the operator, differing concepts of applications between operators, as well as differing perspectives on prioritising commercialisation in the domestic and global markets.

In the third section, I discuss the interactions among the committed players whose trials and errors in the process of appropriating generic technological offerings into specific services led to finding certain niche areas of WiBro services. In these niche areas, innovation took place in appropriation and use whereas the players were actively committed to developing and deploying WiBro service into commercial use.

Last, I conclude with a discussion on the observed divergence and discrepancies that arose during the process of appropriating the single-standard technology into specific commercial service products. These products represent inherent complexities and uncertainties in the innovation process, especially involving large-scale infrastructural innovation.

5.1 From alignments to competition: Towards the regulatory decisions-making

This section discusses how multiple interests have been aligned, realigned and configured towards the commercial deployment of WiBro systems and services. The time range included in this section falls between the reallocation of the 2.3GHz frequency band for Portable Internet (WiBro) use in 2002 and the licensing of the spectrum in January 2005. As the spectrum was allocated for Portable Internet use in October 2002, separate alignments emerged among the players including system vendors and network operators who sought to prepare for the commercial launch of the systems they regarded as appropriate and competitive for the emerging telecommunications service market. Their attempts to deploy commercial Portable Internet systems were, however, subject to the single-standard setting through TTA, whereas the network operators were to be selected through spectrum licensing.

In this section, I examine the emergence and further configuration of these alignments. First, I discuss the initial alignments that were spontaneously formed towards the commercial deployment of Portable Internet systems and services upon reallocation of the spectrum resource in the 2.3GHz frequency band. Second, I

discuss how the alignments were further reconfigured in accordance to the specifications chosen through the standardisation of Portable Internet. Third, despite the degree of closure reached at the level of standardisation, I examine how the competing and diverging visions of WiBro services were incorporated in the network operators' visions and plans for future WiBro service.

5.1.1. Emerging alignments towards the commercialisation of Portable Internet service

In December 2002, the South Korean government reallocated the 2.3GHz frequency band for the use of a single national standard-based Portable Internet service. This was very much the result of coordinated discussions and debates about the efficient use of the spectrum at the 2.3GHz frequency band, which involved diverse interests from industry, government, and academia. The generic vision of Portable Internet service was shaped through coordinated discussions as a portable type Internet service providing high-speed wireless access to the Internet, with a degree of mobility added to the Internet service. The major telecommunications carriers, including the fixed-line broadband Internet, mobile operators, and systems manufacturers, had thus been largely committed to the vision of an emerging Portable Internet service, which was renamed WiBro in 2004. The vision had been generic, carrying various future choices and solutions to be made by the involved players towards commercialisation.

Alignment and competition then arose towards the commercial deployment of the future service, which was subject to further regulatory decisions over spectrum licensing and standards setting. In fact, multiple interests were aligned to the generic vision of Portable Internet, carrying each one's own interests, concerns, views, and positions towards the implementation of Portable Internet service. Upon MIC's decision on the reallocation of the 2.3GHz frequency band for Portable Internet use, the leading fixed-line broadband carriers and mobile operators began preparing for the implementation of Portable Internet service by organizing their own teams and departments to secure the spectrum license needed for the operation of the service (MIC, 2004b).

The domestic and foreign system manufacturers also undertook the development of Portable Internet systems to be deployed for trials, competing against each other to set a single standard for the Portable Internet. Initial approaches by these players differed to a degree in technology choice and the alignments they formed. Samsung Electronics collaborated with ETRI to develop and implement HPi technology. LG Electronics collaborated with ArrayComm, the U.S. company developing a wireless access system, to develop the next-generation high-speed wireless access system, i-Burst (Choi, 2003b). POSDATA collaborated with Broadstorm to develop a commercial Portable Internet system (Lee, 2003b). Although the development of HPi technology was coordinated through the government research institute, others were emerging in the market as near commercialisable products.

Separate alignments were also formed by the existing fixed-line broadband carriers and mobile operators as they projected differing goals in implementing Portable Internet service. The fixed-line broadband carriers including KT and Hanaro Telecom were eager for early commercialization of the Portable Internet service, based on foreign technologies that were readily available: Time to market was their key concern (Kim, 2003c). Although KT and Hanaro had sponsored a government-coordinated R&D project on the development of High-speed Portable Internet (HPi), this did not prevent them from pursuing the technology they preferred for Portable Internet service. Furthermore, failing to meet the time to market seemed to carry risks, including overlapping investments on fixed wireless Internet with the diffusion of the 2.4GHz frequency-band-based Wireless LAN service. The fixed-line carriers, KT and Hanaro Telecom, thus teamed up to request early licensing of the spectrum resource to the government. LG Electronics joined their alignment to pursue early implementation of the service, based on foreign technological systems on which the company had been collaborating (Kim, 2003b). However, SKT, the leading mobile operator, insisted on seeking technology leadership prior to spectrum licensing. SKT was thus aligned with Samsung and ETRI, the key developers of the HPi system, whose interests lay in matching the time for spectrum licensing with securing IPRs, thereby enhancing technology leadership in the global telecommunications market (Lee, 2003c).

The concurrent rise of alignments towards the commercial deployment of Portable Internet systems and services thus represented the multiple interests whose concerns and aims were diverging as they approached the commercialisation of Portable Internet. Despite their initial alignment towards the shaping of the generic vision of Portable Internet, separate yet concurrent alignments were formed to compete through standardisation and spectrum licensing. For spectrum licensing, disputes arose on such issues as who among the fixed and mobile carriers would be more eligible and better capable of providing Portable Internet service. Regarding standardisation, disputes arose around the technological choice between home-grown or foreign, and whether to have a single national de jure standard or multiple de facto standards initially (Chung, 2003a).

Such disputes were to be settled through the processes of standardisation and spectrum licensing. The competing alignments were to be reconfigured as the processes finally reached regulatory decision making. The following section thus examines how interests were realigned and how relationships reconfigured in response to decisions made in the standardisation of Portable Internet and spectrum licensing in the 2.3GHz frequency band.

5.1.2. Reconfiguration of alignments through regulatory decision-making

As HPi was chosen as the base technology through standardisation at TTA, the alignment between Samsung and ETRI, the key collaborators in the technological development, was strengthened to lay the ground for the Portable Internet service to be built on high-speed Portable Internet technology. Others who had intended to enter the emerging service market with other technological choices had to either forgo or change their goals. The various players, including manufacturers of telecommunications systems and handsets, as well as network operators, were thus realigned or reconfigured towards the additional specifications of Portable Internet service.

Significant realignments and dealignments took place among system manufacturers that had intended to enter the emerging service market by building alliances with the

operators. The result of choosing HPi technology as the baseline for a single standard brought changes to their relationships with the operators as well as with other vendors. The vendors' relations with the operators in promoting their own choice of technology for the service weakened as the need to promote a preferred technology base diminished. At the same time, alliances among system vendors faced further challenges. Although Samsung, as a core developer and manufacturer of the HPi system, had a firm position as the future producer of the system, others that had not been aligned with HPi had to undergo significant shifts in their relationships with their collaborating partners. POSDATA, which had been aligned to the development of the i-Burst system in collaboration with Broadstorm, shifted its route by adopting the newly specified technology base. POSDATA began collaborating with Walbell Technologies[41] to develop a Portable Internet system based on the new specifications (Kim, 2004a). Meanwhile, ArrayComm, the U.S. company that had collaborated with LG Electronics, gave up the development of a Portable Internet system whereas LG Electronics shifted and extended its alignment with other developers and manufacturers in the development and implementation of a Portable Internet system[42] (Kim, 2005c). The system manufacturers were thus realigned and reconfigured in response to the standard setting of Portable Internet.

Such was a significant reconfiguration of alignments resulting from the single standard policy. Yet, the degree of closure achieved through the choice of a technology standard did not quite limit further choices in appropriating the technology: for example, who would provide the service, and how the services would be provided. The operators of both fixed and mobile communications came to pursue licensing, where they came to compete for a limited number of licenses. The major fixed-line carriers, including KT, Hanaro Telecom, and Dacom, and the mobile carriers, including SKT and KTF, vied for spectrum licenses for WiBro. Subsequently, disputes and debates arose about who would be more eligible and

---

[41] Walbell technologies, Inc. was established by researchers from Broadstorm.
[42] LG Electronics, while excluded from the HPi Consortium, built a collaborative relationship with Intel for the global standardization of WiBro/Mobile WiMAX, and further pursued the development of Portable Internet systems by collaborating with Nortel Networks, a Canadian company, which merged with LG in November 2005. (Kim, Taejin. "Nortel attacks WiBro market through 'LG-Nortel'" Digital Daily, 20 September 2005)

capable of operating the emerging service. The government coordinated and conducted research, and held forums and public hearings (KISDI, 2004) to establish a framework and specific criteria upon which to make decisions on spectrum licensing. Varying knowledge and opinions were gathered, then merged to produce certain results and suggestions in shaping a regulatory framework for spectrum licensing for the WiBro service.

Consequently, a regulatory framework was prepared for granting three licenses, regardless of the existing service boundary between the fixed-line and the mobile, through a comparatively stringent selection process[43] (Choi, 2004a). The granting of three licenses suggested that the competition would bring infrastructure investment as well as the provision of a variety of applications services (MIC, 2004b). Other issues relating to licensing were also decided, such as the conditions for licensing and the length of time and pricing for spectrum use. Meanwhile, according to the spectrum licensing policy of MIC, candidates were to be assessed using preset criteria on their capacities and competencies for the future operation of WiBro service (MIC, 2008). Candidates were therefore required to effectively demonstrate their capacities and capabilities against what had been framed as the WiBro service. The spectrum being the critical and yet 'scarce resource' requiring regulatory rules and frames for allocation and use, the emergent service was to be further shaped through competing visions, future anticipations, and regulatory decision making about the licensing and use of the 2.3GHz frequency band.

5.1.3. The competing visions of WiBro towards spectrum licensing

Since as early as July 2003, MIC had coordinated a working group to prepare for the introduction of WiBro service to the market. This consortium included the Korean Information Society Development Institute (KISDI) and the Electronics and

---

[43] The spectrum licensing policy of MIC in Korea was based on assessing business plans submitted by the candidates. MIC first decided on the feasibility of licensing based on certain criteria such as benefit to the public. Once the possibility for licensing was confirmed, the plans were assessed through quantitative as well as qualitative methods (Choi, 2004). This comparative selection was donned '*Beauty contests*' in which the "government invites applications that are rated according to some pre-set criteria. Licenses are allocated to those whom the government believes best meet the stated requirements" (Xavier, P., 2001, Licensing of Third Generation (3G) Mobile: Briefing Paper, ITU Workshop on licensing 3G Mobile, Geneva.

Telecommunications Research Institute (ETRI), the two leading government institutes in the telecommunications field[44] (Ahn, 2009; MIC, 2005a). The working group was responsible for bringing forth policy recommendations for the content and method of spectrum licensing for WiBro service at the 2.3GHz frequency band. The group thus carried out anticipatory research on various issues including the use, demands, and positionings of the emerging service. Policy suggestions and recommendations were finally prepared in August 2004, and the public hearing on WiBro Licensing Policy took place on 12 August 2004, organized by MIC and cohosted by KISDI and ETRI (MIC, 2006b). The purpose of WiBro licensing policy was to promote WiBro service for the public to enjoy high-quality, low-price wireless Internet service; to bring about workable competition[45] where the existing market could efficiently operate; and to reduce overlapping investment (MIC, 2004b).

At the public hearing on WiBro licensing policy, the vision and the concept of WiBro service were put forward as a service that would enable high-speed wireless-Internet access whenever and wherever mobility was at hand. It was positioned between the existing mobile telephony and wireless LAN with regard to such aspects as data-transfer speed, mobility, and cell coverage (MIC, 2004b). WiBro was expected to complement high-speed broadband Internet and wireless LAN by providing mobility, and to provide wireless Internet service at lower cost while having a higher data-transfer speed than the current mobile telephony. Table 1 shows the comparison of WiBro service with the existing wireless LAN and mobile telephony as of August 2004. The voice service was regarded as challenging with the current technological capability. Also, to support voice application, further requirements for supporting mobility, QoS, coverage expansion, and more were projected to incur increased unit cost for the system and overall investment fee. However, the evolution of WiBro service was further anticipated either to reach a

---

[44] The Ministry of Information and Communication organized and operated the "Working Group Responsible for Introduction of WiBro Service" from July 2003 to September 2004 (MIC, Introduction and Promotion of Portable Internet (WiBro) Service. (11 March 2005))
[45] The term 'workable competition' is linked to the role of MIC stated in Electronic Communication Business Law as "Establishment of efficient competition system, fair competition environment' (Article 33 Section 4).

data-transfer speed of up to 50Mbps while maintaining the current mobility, or to enhance the mobility up to the level of mobile telephony (250km/h) to embrace applications including VoIP (Voice over Internet Protocol). Thus, WiBro was expected to play a complementary role to mobile telephony while competing to an extent with W-CDMA (Wideband Code Division Multiple Access) which was being introduced for advanced mobile data service along the evolution of the existing mobile communications networks in December 2005.

Table 6 Comparison with Wireless LAN and Mobile telephony (MIC 2004)

Classification	Wireless LAN	WiBro	Mobile telephony
Application service	Wireless Internet	Wireless Internet	Voice and wireless Internet
Data speed/ subscriber	1Mbps and up	Approx. 1Mbps	Approx. 100kbps and up
Mobility	Walking	60km/h and up*	250km/h and up
Terminal	Desktop, laptop, PDA	Laptop, PDA, Mobile phone	Mobile phone, some PDA
Cell radius	Approx. 100m	Approx. 1km	1km~3km
Tariff system	Flat rate	Volume rate + Flat rate	Volume rate

* Although it is possible to provide seamless wireless Internet service at the speed of 60km/h and up, data transfer speed gradually decreases with the increase in mobility.

Yet, such was the generic frame for the future WiBro service. Upon preparing the licensing policy for the service, competing visions arose from operators who were pursuing the granting of licenses for the commercial deployment of the service. Although the candidate network operators had generally been bought into the generic vision of WiBro as a service in fixed and mobile convergence, the service positioning and further envisionings of WiBro service differed to a degree. Among other reasons, visions diverged due to operators' varying backgrounds including their histories, current market positioning, and relations to technological offerings. WiBro offered a range of choices from interested operators in its relationship to existing services, as well as service types and strategies. However, the differing visions and choices were further driven toward competition as various operators, both fixed and mobile, approached the limited number of licenses the spectrum space would offer.

By early 2004, KT, Hanaro Telecom, Dacom, the fixed-line carriers intended to enter the WiBro market, and three mobile carriers, SKT, KTF and LGT were also preparing to commercialise the service (Baek, 2004b). Partly embracing and sharing what had been anticipated and estimated by KISDI and ETRI on the use and adoption of WiBro service, each put forward its own interpretations and positioning of WiBro service in ways that would differentiate their offerings from others and build their competencies based on their current resources, past experiences, and their future plans.

KT,[46] the largest and leading fixed-line carrier in Korea, regarded Portable Internet as a service that was to provide seamless Internet access through a fixed-mobile convergence network, ultimately expanding to ubiquitous networking service (Hwang, 2004). KT characterized the Portable Internet as a service providing Internet access at similar speed to that of the fixed-line ADSL, where the contents of fixed-line Internet would be provided (Ko, 2004). Its existing fixed-line and wireless infrastructures and WiBro were to be seamlessly connected by applying handover and roaming solutions. Through an open-platform policy for the new wireless-mobile service, the Internet contents available through the fixed-line broadband Internet were to be accessed freely, regardless of the terminals, place, and time. Therefore, Portable Internet for KT was regarded as an extended service for outdoor use of fixed-broadband Internet. While providing a bridging service for fixed-mobile convergence, it was expected to form one of the core network services in the ubiquitous networking environment in the future. Although KT's major interest lay in entering the mobile market at the verge of market saturation for fixed-line communications, it positioned KTF, its mobile subsidiary, as a collaborator for building WiBro networks and providing bundled services for the fixed-mobile convergence service (Ko, 2005). Through collaboration with KTF, KT planned for 'WiBro Swing' service which would have WiBro service seamlessly connected with wireless Internet (Nespot) or mobile telephony (CDMA2000 1x EVDO). The major

---

[46] KT is the leading telecommunication service provider in South Korea. KT was originally established in 1981 as a public corporation, and was privatized in 2002 as a carrier and operator of wired and wireless telephone and Internet-service networks. It further merged with its mobile subsidiary KTF (KT Freetel) in 2009 (http://www.kt.com).

concern for KT, however, was to develop outstanding content that would stimulate the diffusion of WiBro, while differentiate it from existing mobile services. Services such as Multimedia Messaging Service (MMS), Location Based Services, IP game, and VoD were considered to have outstanding content, whereas convergence services with wireless LAN, Digital Mobile Broadcasting (DMB), and GPS were regarded as key pathways to prepare for the convergence market for fixed and mobile as well as broadcasting services. Laptops and PDAs were expected to be the major terminals during the introductory stage for WiBro service as the early services, focused on access to information service via the Internet (Park, 2005).

Hanaro Telecom, the second largest provider of fixed-line broadband Internet had also been concerned with market saturation of fixed-line broadband Internet. Portable Internet was thus considered the company's next growth engine (Byeon, 2004). However, unlike KT and others, Hanaro Telecom was the only carrier among the candidates that had not been aligned with existing mobile operators and service in organizational relations. Hanaro Telecom envisioned WiBro as evolving from the fixed-line Internet technology carrying some complementary service as well as encouarging a greater impact for the existing fixed-line broadband infrastructure. WiBro was therefore considered to fall inside the boundary of the fixed-line communications service, which the fixed-line carrier should pursue in the evolving telecommunications landscape. Furthermore, it viewed 3G and High-speed Downlink Packet Access (HSDPA), which were evolving through mobile networks, to be competing with WiBro, and insisted that the licenses for WiBro and 3G/HSDPA should not be held by the same operator (Yoon, 2004). Hanaro, the fixed-line carrier, expected WiBro to be evolving towards the high-speed broadband Internet with added portability and mobility. The telecom company was pursuing enlargement of its market share by acquiring Thrunet, then the third largest broadband carrier, which would ultimately bring Hanaro's broadband market share up to 30% with more likelihood and strength to deliver new services related to Internet including VoIP and IP-TV (Galbraith, 2005). Hanaro Telecom further pursued joint collaboration with existing and leading portal services of NHN and Daum communications, planning to rollout 'NHN WiBro Zone' and 'Daum WiBro

Zone' (Kim, 2004c). Furthermore, it planned to provide an open platform through which the contents of the existing fixed-line Internet could be shared, while limiting the openness for a small amount of outstanding content. Such service positioning was intended to differentiate WiBro service from existing mobile services while taking advantage of its own IP back-bone networks. Yet, Hanaro's relative independence from the existing mobile services also brought challenges to its intention of being granted a license for a fixed-mobile convergence service (Baek, 2004a). Although Hanaro Telecom's strategic approach to WiBro was deeply grounded in the company's stable and effective position as a fixed-line carrier, it was considered by many others that the company would require close alliance with a mobile operator for efficient and effective implementation of WiBro systems and service (Baek, 2004b).

In contrast, SK Telecom (SKT), the leading mobile operator with more than 18.6 million subscribers as of December 2004, had not been aligned with the fixed-line carriers in pursuing the commercialization of WiBro. Other mobile operators among those interested in the commercialization of WiBro service—KTF and LGT—had aligned themselves with the fixed-line communications-sector organisation under their corporate heads. Having been positioned as the leading mobile telephony and mobile communications operator, however, SKT envisioned WiBro as a complementary service to the existing mobile service for its high-speed data-transfer capability with a low subscriber fee (Seo, 2004). SKT therefore planned data-intensive services such as VoD, file downloading, and other multimedia services at a low flat rate, while placing other mobile services of small scale data such as email, Short Messaging Service (SMS), and online banking as appropriate for low- to mid-speed mobile service at volume-rate pricing. WiBro was thus to be provided to more than 84 cities with designated 'hot zones,' according to their strategic match with the demands for large-scale and high-speed mobile data communications. Therefore, SKT regarded mobile handsets, rather than laptops, as necessary for the diffusion of WiBro service (Baek, 2004a). The contents services for WiBro were also linked with those of mobile telephony whereas SKT's mobile platforms such as Nate and June had been providing more than 680,000 mobile customers. Based on its existing

mobile infrastructure and service, SKT also planned to develop outstanding applications for mobile broadband service that would be operated on closed platforms, in contrast to the fixed-line carriers' open-platform policy towards WiBro content services (Kim, 2004c). Thus, SKT asserted its strength as the most adequate and competent WiBro service operator, and claimed that therefore it should be granted a spectrum license for the operation of WiBro service. For SKT, WiBro was viewed as aligned with the existing mobile service as both were built on the technologies (e.g. OFDM, Smart Antenna, MIMO[47]) to be implemented for fourth-generation (4G) mobile communications (Baek, 2004a). WiBro was therefore being positioned in the evolving path towards the next-generation mobile-communications service.

There was also a consortium of fixed and mobile operators that had been formed to obtain spectrum licenses for WiBro service. Dacom, the third largest fixed-line broadband carrier, had intended to enter the emerging wireless and mobile market through an alliance of the fixed-line carriers and mobile operators under the LG Group: Dacom, Powercomm, and LG Telecom[48] (Baek, 2004a). Based on the companies' infrastructures for the fixed-line and mobile services, LG Consortium focused on its strength in efficiency in implementing and operating WiBro, the fixed-mobile convergence service. LG Consortium regarded WiBro service as an emerging service with an emerging market during a fixed-mobile convergence era. Rather than regarding WiBro as a bridging service or as having been extended from the existing services, LG Consortium insisted on their conceptualization of WiBro as the fixed-mobile convergence service that would ultimately evolve towards ubiquitous networking by integrating with the location based service (LBS), telematics, home electronics, transportation, broadcasting, and more (Baek, 2004a). However, Dacom withdrew from the competition to secure a license for WiBro service in October 2004 with its final decision to concentrate on the buyout of

---

[47] MIMO: Multiple Input Multiple Output.
[48] Dacom was a fixed-line operator of long-distance telephone service, and had been operating VoIP service since 2003. Powercomm had been one of the largest providers of high-speed broadband Internet access. Dacom and Powercomm merged with LG Telecom, the third largest mobile operator in January 2010. As of 1 July 2010, LG Telecom changed its name to "LG U+".

Thrunet[49] (Kim, 2004b), the first and one of the leading broadband Internet carriers in Korea that had been under legal management since 2003. Enlarging their market share for telecommunications service was thus prioritized whereas the Consortium decided to pursue indirect involvement in WiBro service business through MVNO or a business alliance. (http://4g.telecomskorea.com/page/53/)

Spectrum licensing for WiBro service was approached by competing yet evolving interests in next-generation and fixed-mobile convergence communications service. Although being framed as an emerging service that would complement and overcome limits of existing wireless LAN and mobile telephony, the generic vision of WiBro allowed for varying strategies for the implementation of WiBro service. Based on the spectrum licensing policy for WiBro, three licenses were finally allocated to three operators, KT, SKT, and Hanaro Telecom,[50] ultimately allowing the differing interpretations and approaches to bring about commercial WiBro service. The granting of three licenses to the fixed-line carriers and a mobile operator did not quite end the debate on the differing choices, appropriating generic technological capabilities to specific service offerings.

The competition among the candidate network carriers towards spectrum licensing was indeed a process of claiming of their own eligibility, capacity and capability for operating the emergent service. WiBro service was thus to be shaped based on the differing interpretations and approaches by the operators, while their initial appropriation of the generic capabilities of WiBro would further depend on their relations and interactions with others that were also involved in the development and the implementation of the technology and the service.

5.1.4. Summary

This section demonstrated the process of reconfiguration of alignments and a degree of closure reached through standardisation, vis-à-vis the divergence in additional

---

[49] Thrunet had been registered for legal management in 2003, and merged with Hanaro Telecom in January 2006. Hanaro Telecom then merged with the leading mobile operator, SK Telecom, in 2008.
[50] Licenses for WiBro service were allocated to KT, SKT, and Hanaro Telecom in December 2005. KT planned an initial service launch in April 2006, whereas SKT and Hanaro Telecom's commercial services were to launch in June 2006.

choices towards the appropriation of the technology into specific services. I first observed the concurrent rise of competing interests and alignments that emerged and evolved in response to the series of regulatory decisions linked to the commercialisation of WiBro. Upon government reallocation of the 2.3GHz frequency band for Portable Internet use, multiple interests were mobilised to form their own alignments, according to their needs and aims for the emerging service market. However, their alignments were partially reconfigured as a result of standardisation of Portable Internet, which came to allow only one particular specification for the commercial deployment of Portable Internet systems and service.

Despite the degree of reconfiguration of the alignments towards the implementation of a single standard for Portable Internet, however, there arose divergent concepts and visions for the Portable Internet service to be deployed by network operators. A number of players competed for spectrum licensing while each proposed and suggested divergent yet competing visions of Portable Internet service. The players planned and addressed different applications and business models, whose histories, current needs, and future envisionings varied to a degree..

Such diverging concepts and ways of appropriating WiBro reflected their own current positions, capacities, relations, and future strategies in the telecommunications market. KT as the leading fixed-line carrier and a corporate head carrying the mobile subsidiary KTF had promoted the vision of WiBro as a mobile extension of fixed-line ADSL, which would be complementary to existing services on the mobile network. Hanaro Telecom, the second largest and a leading fixed-line carrier insisted that WiBro was a service evolving from the fixed-line Internet, thus to be operated by the existing fixed-line carriers as the next generation telecommunications service. SKT the leading mobile operator, in contrast, consistently positioned WiBro as a complementary service to existing mobile-network-based services, whereas the LG Consortium, formed among the fixed-line carriers and mobile operators under the LG corporate group, insisted on the vision of WiBro as a fixed-mobile convergence service.

Three licesnses were granted to two fixed-line carriers, KT and Hanaro Telecom, and one mobile operator SKT, resulting in embracing a degree of divergent visions and concepts of Portable Internet service. Indeed, this reflected the variant modes and ways of appropriating the generic capabilities of Portable Internet that had reached a degree of closure in the technology choice through the single-standard setting. Commercial WiBro service was thus to be shaped through differing deployment strategies, differing aims, and differing outlooks on the future telecommunications service market.

The following section more closely examines the complex interactions among the divergent players in the process of bringing about commercial WiBro service in the domestic market. The deployment efforts for WiBro service reflect the complex process of appropriating the generic capabilities of WiBro, to be integrated into specific WiBro products and services.

5.2 From competitions to divergence: towards the commercial deployment of WiBro services

In December 2005, the three network operators - KT, SKT, and Hanaro Telecom, were granted licenses for the 2.3GHz frequency band. WiBro service was thus to be further shaped through the competing visions and diverging ways of configuring generic technical capabilities to provide specific services. Furthermore, commercial WiBro service, having been scheduled to be launched by June 2006, was approached with varying interests, aims, and objectives by diverse players including the government, system vendors, operators, content providers, and others. Various issues arose, linked to the commercial deployment of WiBro service, which led to certain discrepancies among those who were involved in the process of shaping commercial WiBro service.

This section discusses the process of commercial deployment of WiBro service as a process of appropriating the generic technical capabilities of WiBro by the operators, system vendors, and many others. I particularly examined the conflicts and discrepancies that arose among the collaborators of the deployment of the commercial WiBro products and services. I focused on the processes that fall within

the approximate time range of 2005–2009, during which the struggles to bring about commercial WiBro service resulted in many disputes and little market adoption.

First, the section examines the emerging conflicts upon commercialisation of WiBro, alongside the shared goal of globalisation. Then, it further explicates the discrepancies that arose between the coproducers of WiBro during the process of commercial deployment of WiBro products and services. Last, it examines the gap between the domestic and the global market uptake. These observations led to addressing the divergence and further uncertainties experienced during the process of appropriating the generic capabilities of WiBro to specific service products.

5.2.1. Towards domestic deployment of a global standard

By the time the licenses for WiBro service had been granted to the three operators, the service had become closely linked to a global standard and service named Mobile WiMAX[51]. WiBro was no longer a service confined to the domestic market. As a single domestic standard, the WiBro standard had been harmonized with an international standard IEEE802.16[52], and a degree of IPRs and technical inputs from domestic vendors were included in the global standard (Puthenkulam 2009). Subsequently, the Korean innovation players actively pursued further standardisation through their unprecedented participation and commitment to the global standards fora. In particular, the commercial deployment of WiMAX products, including WiBro in Korea, were promoted through the WiMAX Forum[53] whose role included

---

[51] Mobile WiMAX is a service name for Worldwide Interoperability for Microwave Access. Further information on Mobile WiMAX in http://www.wimax.com/wimax-technologies-standards/what-is-ieee-80216e

[52] TTA Phase 1 was revised to conform to IEEE802.16TGe Draft v.5 in December 2004. The standardisation of IEEE802.16e was approved as an international standard of IEEE802.16e-2005 in October 2005.

[53]WiMAX Forum was established in June 2001 as an industry-led organization certifying and promoting the compatibility and interoperability of broadband wireless products based on IEEE Standard 802.16. (http://www.wimaxforum.org). Korean industry players including Samsung Electronics, KT, POSDATA, SKT, and LG Electronics have participated as Members of the Forum since the end of 2004. (Kim, Dae-jung. 2005 'WiMAX Forum' TTA Journal 99, 152-159p). TTA of Korea was selected as the First WiMAX Certification Lab in Asia, to certify compatibility and interoperability of WiMAX products (www.WiMAXForum.org/news/828)

reaching compatibility and interoperability of the standards, as well as certifying the products to be deployed around the world (Kim, 2005d).

The commercial deployment of WiBro service in the domestic market had thus been closely linked to overseas activities and roles played by the national innovation players. The domestic WiBro service deployment was regarded by the Korean innovation players as an important process and precondition for gaining the technological leadership in the global market for Mobile WiMAX.[54] An early commercialization to implement the first Mobile WiMAX service in the world was thus strongly pursued in Korea, towards which the government, system vendors, and the developers of WiBro technologies, as well as the operators to an extent, were closely aligned.

Yet, at the same time, the vendors and the network operators perceived differing urgencies in the early commercialisation. For the system vendors, including Samsung and POSDATA, an initial adoption of the emerging communications technology and service was expected to provide a 'reference site' upon which the potential wider adoption of the technology and service would be reflected and projected (Kim, 2005d). Thus, commercialisation was closely linked to their attempts at overseas sales of their own products, where time-to-market would be critical for successful introduction, as was reflected in an interview with an executive director at POSDATA with Electronic News in Korea:

> It's more desirable to make reference through commercialization first and
> then expand the base rather than distributing time and distracting one's
> attention for securing interoperability between systems. If we miss the time

---

[54] In the newspaper interview with a Project Manager for next-generation mobile communications in the Ministry of Information and Communication, it was mentioned that 'the profile is key to service implementation (of Mobile WiMAX) where only the technologies that have actually been implemented could be proposed. ... So WiBro is the only one that can be proposed as the profile. ... In case interoperability is achieved through WiBro profile, the countries implementing Mobile WiMAX have to use WiBro technologies. Korea can therefore leap from a technology importer to technology leader and exporter' (Song, J.R. 2005. 'WiBro confirmed as International Standard' Digital Times, 16 November 2005).

for presenting the reference, it may become impossible to open up the global market (for WiBro).

<div align="right">

(Interview quoted in 'WiBro, Conditions for Success (4) Let's go to the world' Electronic news, 31 January 2005).

</div>

However, operators were more keen on securing wider interoperability of standards through collaboration among international operators and vendors, prior to or in parallel with the domestic implementation of the systems and the service. The urgency for early commercialization to provide a 'reference site' for successful implementation posed certain limits and difficulties for operators. This led network operators to request a postponement of the initial launch of WiBro service in the domestic market. This tendency was reflected in an interview with the Director of SKT, who commented on learning from SKT's experience during the world's first commercialization of WiBro:

> In fact, from the perspective of telecommunications service providers in the process of the world's first commercialization, with WiBro in Korea, only Samsung [and the manufacturers] responded actively. As a result, the initially implemented network systems were expensive. If the components were standardized as in computers, it would have been easier to [out]source and could have made purchases on the components less expensive. But the base stations, routers, these were all unstandardised and we couldn't but depend upon Samsung. … For telecommunications carriers, complete standardization? And then perfect competition. … Since these didn't exist in the beginning we had to depend upon Samsung, and the prices for the systems were expensive. … These were the difficulties during the initial introduction. The standards—they weren't fully standardized like in computers. It would have been nice if it had been so, but we could only be dependent upon Samsung.
>
> <div align="right">(Director, SKT, 13 September 2010)</div>

Along the discrepancies arising from the differing urgencies in the domestic commercialization of WiBro, efforts aimed at the commercialization and

globalization of the domestic technology and service were coordinated under domestic IT policy, IT839 strategy, which was led by MIC (MIC, 2005b). The IT839 strategy aimed to introduce the world's first services and products by promoting eight service areas, building three infrastructures, and developing nine new growth engines. The eight service areas included HSDPA/W-CDMA, WiBro, Broadband convergence service, DMB/DTV service, u-home service, Telematics/Location-based service, RFID/USN application service, and IT service, revised for the u-IT839 strategy (MIC, 2005b). Upon the development and the standardization of WiBro, WiBro was increasingly considered one of the core technologies to fulfil such policy aims for the development and the implementation of new ICT-related products and services. Under such policy aims and objectives, commercial WiBro service was required to take off by the first half of 2006 (MIC, 2006a, 15p).

An initial milestone for driving the world's first implementation of WiBro service was set by MIC, to showcase WiBro service at the APEC meeting in Busan in November 2005. The demonstration of actual services of WiBro to the representatives of APEC member countries as well as industry members was considered a key site to promote the standardization of IEEE802.16e and the worldwide diffusion of Mobile WiMAX, particularly based on the WiBro profile (Kwon, 2005). Other objectives were also driven with the goal of demonstrating at APEC, such as motivating Samsung and other manufacturers to develop commercial WiBro systems in time, which would be critical in the diffusion of the services and technologies. KT was selected as the main demonstrator of WiBro service, whereas SKT was responsible for demonstrating HSDPA (Lee, 2005). KT, as a sole demonstrator of WiBro service, aggressively prepared for the demonstration; the intention of the demonstration at APEC was extended to showcase a precommercial trial service, prior to the actual commercial launch in the domestic market to take place in 2006. The APEC demonstration of WiBro was therefore expected to be the prelude for the domestic commercial service as well as the worldwide adoption of Mobile WiMAX.

On 15 November 2005, WiBro was successfully demonstrated to the representatives of the APEC member countries, major telecommunications operators, vendors

around the world, the WiMAX Forum, other global-standards organisations, and many others. Most advanced WiBro handsets were prepared in close collaboration with Samsung, and various applications such as multimedia messaging, Video-on-demand (VoD), video telephony, broadcasting, navigations, and home networking were successfully demonstrated. Through Tablet PCs connected to the WiBro network, real-time news from CNN and Arirang TV and music videos were shown, while P to P video conferencing between multiple sites were demonstrated while traveling by bus to and fro the conference sites and a few other destinations. The seamless connection and the operation of the services at APEC were then followed by positive outlooks and anticipation of the actual implementation and adoption in domestic and foreign markets (Song, 2005b).

Indeed, the seamlessly coordinated showcase of WiBro services presented many promises and possibilities in the deployment of next-generation, convergence services. It was, to an extent, working proof of the technical performance of WiBro as one of the most advanced types of telecommunications services. Yet, the concerted efforts to bring about the most advanced services of WiBro were effective only to the extent of showcasing their utmost capacities, unhindered by concerns that were subject to real market conditions and the environment.

The following section examines further discrepancies that arose in the course of actual deployment of commercial systems and the services of WiBro in the Korean domestic market. The discrepancies presented a chasm among the interests of the innovation players who together were involved in the process of coproducing commercial WiBro service.

5.2.2. Diverging choices and rising discrepancies: the commercialisation of WiBro

Alongside the rising visions and hopeful attempts towards globalization, there were also negative forecasts and perceived challenges in the domestic commercialization of WiBro service. In particular, with the advent of HSDPA, which was rapidly evolving from the existing 3G mobile-communications network technology, WiBro was increasingly anticipated by some to be repositioned as a competing service

rather than being complementary to HSDPA (Na, 2005). The future of WiBro was therefore increasingly questioned. Adding to this outlook on the emerging service, Hanaro Telecom returned its license and gave up its plan for implementation after concerns about the considerable investment required with little prospect for a return (Song, 2005a). The key reason for Hanaro Telecom's decision was to concentrate on and strengthen their competency in their core business, which was fixed-line high-speed Internet. Hanaro Telecom had, in fact, been at the forefront with KT of securing the spectrum license since the very beginning of the reallocation of the 2.3GHz frequency band for Portable Internet use. Furthermore, it had recently made agreements with SK Telecom to share their base stations and access networks for WiBro service deployment in areas countrywide excluding Seoul and six cities, which would bring them both an efficient and large amount of savings in investment in the implementation of WiBro service (Kim, 2005a). Despite the alliance being formed, Hanaro Telecom eventually decided to drop the license as the deadline for the payment of the license fee was approaching (Kim, 2005b).

WiBro service was thus to be implemented by KT and SKT. This was a significant change from the original scenario that had been planned out through the WiBro licensing policy to promote the service through effective competition in the market, by enrolling three operators. Furthermore, the roadmaps for the implementation of WiBro differed to a degree. SKT was rather reserved and hesitant about stepping into actual deployment of the emerging service since the spectrum license had been granted. In fact, while SKT had consistently insisted that WiBro should play a complementary role to its own 3G network, the two differing services seemed to carry inherent uncertainties towards the future relationship, especially with the rapid advancement of the 3G technologies from WCDMA to HSDPA:

> From SKT's viewpoint, although we actively participated in the WiBro business since the writing up of plans for it, there were already disputes around the cannibalization issue. As there was a degree of overlap between mobile telephony and the WiBro business boundary; we couldn't really actively invest in WiBro.
>
> (Director, SKT, 13 September 2010)

The boundary issues related to mobile telephony and WiBro had been a source of concern and much disputed among industry players, especially network operators, since the conceptualization of Portable Internet service. Furthermore, HSDPA, with its improved capacity for downlink data rates from that of WCDMA was further anticipated to be either complementary or competitive to WiBro, depending on terminal types, and to compete when applied to handset-type mobile terminals with voice service included (Park et al., 2005). Although SKT's initial service vision had been to provide seamless handover between the WCDMA and WiBro networks while using the mobile phone-type terminals, the evolving relationship between the two networks brought about further challenges to SKT's implementation of WiBro service.

Meanwhile, KT had planned to take gradual steps, while it foresaw the ultimate destination to be the convergence of various types of services, enabling both data and voice communication to work in a convergence mode of mobile handsets. The future plan for roll out of WiBro service was divided into three stages: Introduction, Growth, and Maturity (KT, 2005). At the introduction stage, KT planned to implement WiBro-only Personal Computer Memory Card International Association (PCMCIA) cards and embedded modems for laptops, and WiBro-only PDAs as well as smart-phone-type handsets having dual mode and dual band for voice and data. In the growth stage and then in the maturity stage, WiBro would gradually be implemented with other services including WLAN, DMB, GPS and CDMA, finally reaching converging service through multi-mode, multi-band[55] mobile terminals. Among the services to be converged with WiBro, voice-communications service seemed most critical to KT in the long run, to secure its competitive position in the future fixed-mobile convergence service market. Although KT would first implement voice through the CDMA network owned by KT's mobile subsidiary,

---

[55]A multi-mode mobile terminal operates across different standards whereas a multi-band terminal (also frequently called dual, tri, or quad band) is designed to work on more than one radio frequency. KT's roadmap for WiBro suggested up to a triple-band, triple-mode mobile handset that would include a set of standard WiBro, WLAN, and CDMA, or a set of WiBro, CDMA, and DMB. (KT Corporation, The Role of Wi-Bro for the Convergence Era. Asia-Pacific Telecommunity: The First APT Operators Forum, 28-30 July 2005, Seoul, Rep. of Korea)

KTF, VoIP seemed to be an ultimate solution it should pursue, as was increasingly anticipated and suggested by numerous reports and articles on the future of WiBro service (Han, 2005).

Whilst KT's and SKT's approaches towards the commercialization of WiBro differed to a degree, disputes arose with regard to KT's plan for the deployment of VoIP. SKT firmly opposed deploying VoIP in the WiBro network, asserting that the licenses for 3G and WiBro belonged to different classifications of communications services:3G for voice and WiBro for data, which had resulted in differing amounts for licensing fees.[56] However, the regulation governing mobile VoIP had not yet been in place to resolve such a conflict, whereas unsettled disputes further brought about delays in the development of mobile phones for WiBro. In response to ongoing disputes between the incumbent mobile operator and KT, the mobile phone industry did not respond very actively to WiBro marketing, although they anticipated that mobile phones would eventually lead the service in the future (Park, 2006). Under KT's and SKT's differing concepts and strategies, WiBro service was finally launched on 30th June 2006, as scheduled (MIC, 2006d). There was only one type of WiBro terminal available in the market: the PCMCIA card for laptops. Advanced terminals including PDAs, dual-mode, and dual-band terminals, combining WiBro and other wireless standards, as well as multimedia enhanced mobile-phone types, were planned and expected by KT to be introduced in the following months.

Yet, three years after the initial launch of WiBro service, the development and implementation of advanced WiBro devices were still faced with discrepancies among the coproducers of the WiBro service. Even the leading manufacturer, whose urgency lay in developing advanced WiBro devices, was experiencing certain obstacles in pursuing their goal. Among the key obstacles was the network operator's passive approach towards the commercialisation of WiBro service. In particular, the lack of commitment by SKT to deploy commercial WiBro service caused constraints for the leading manufacturer, whose interest mainly lay in early deployment and diffusion of WiBro systems and devices:

---

[56]Mobile operators had paid for the 3G license 1.3 trillion KRW while 175 billion KRW had been paid for the licenses for WiBro (20060112).

Network coverage: … KCC is pushing SKT. SKT is reconsidering its marketability, although this is not very explicit. Expansion of network coverage should precede terminal launch. Fee is a sensitive issue. SKT's promotion activities have been very slight. … The WiBro team at SKT is very small, there are limitation in network coverage, which constrains Samsung. SKT is rather dependent on Samsung. Samsung has many proposals. However, the dilemma lies in the fact that SKT's WiBro team is too small.

(Manager A, Samsung Electronics, 2 September 2009)

Indeed, the manufacturer, in coproducing high-end devices for the new service, was facing certain dilemmas as they met operators' differing plans and strategies towards the deployment of commercial WiBro service. Although KT had been more actively pursuing implementation of WiBro service, differing senses of urgency emerged leading to differing deployment strategies in implementation of WiBro service:

Samsung is in a leading position. We have been approached with the view that WiBro should be implemented with Smartphones. This was our idea from the beginning, yet it wasn't very feasible in the beginning stage. KT is preparing Smartphone+WiBro this year. We have been trying to move KT in this direction. KT preferred Modem-type services.

(Manager B, Samsung Electronics, 2 September 2009)

Although the discrepancies among the coproducers of WiBro services in the domestic market were not easily mediated, such imbalances in vision, aims, and objectives further brought about conflicts and disputes among the players in the commercialization of WiBro service. The differing interpretations of WiBro service, differing senses of urgency in deployment strategies, and differing aspects and degrees of commitment towards WiBro caused discrepancies in the process of coproduction of an emerging telecommunications service.

In the following section, I discuss the resulting gap between the initial visions and anticipations linked to WiBro and actual outcomes in domestic-market adoption. The ongoing pursuit of the global diffusion of WiBro-related standards and products by

the manufacturers and others are observed vis-à-vis the unmitigated challenges faced by the promoters of the wide diffusion of WiBro in the domestic market.

5.2.3. Global diffusion vs. domestic illusion

The eventual launch of WiBro service in the domestic market was closely linked to the aim of the Korean government and the industry that had been aligned towards globalization, especially driven forward through harmonization of the domestic standard for WiBro and the IEEE802.16 international standard. The world's first commercial service in the domestic market was regarded and promoted to be the key milestone to achieve technological leadership in the international standardization as well as in markets abroad (Hong, 2007). Along with efforts linked to globalisation, Samsung the leading manufacturer of WiBro systems and devices in Korea, made its first entry to export the 'home-grown' systems to foreign countries in 2005 (Hong and Kim, 2005)[57], and further expanded its overseas implementation sites to 23 countries with 35 network operators by the year 2007[58](Kim, 2009c). Indeed, the adoption of Mobile WiMAX systems and the service in the overseas market did seem to increase rather rapidly, whereas the domestic market for WiBro was lagging behind.

Furthermore, a subset of WiMAX, under the name 'OFDMA TDD WMAN' was approved by ITU as a new terrestrial radio interface for IMT-2000 in October 2007 (ITU, 2007). This approval meant that as the Korean version of Mobile WiMAX, WiBro was technically included as a profile version of a specification of Mobile WiMAX into an officially designated IMT-2000 family of mobile communications standards. The inclusion of Mobile WiMAX to IMT-2000 had been greatly pursued by a collaboration between the Korean government and the industry, as they were closely aligned with other members and member countries that were supporting the WiMAX standard to be approved as the sixth IMT2000 family standard. Not only did the inclusion bring a promising future for further diffusion of the WiBro profile

---

[57]Samsung made contract with BT to export the Mobile WiMAX pilot system and Internet Protocol Multimedia Subsystems (IMS) in August 2005.
[58] Among the collaborators,Samsung had contracted with 10 operators over 8 countries for commercial service by 2009. Commercial Mobile WiMAX in the United States began on 30 April 2008 (NARS 2009, 23p).

as the 3G mobile standard and service, but it also suggested further linkage towards the next-generation mobile communications standard and service, namely 4G (Hong, 2007; Kim, 2007). The eventual line-up of IEEE802.16 in the 3G radio standard was thus much praised and greeted in Korea, especially by the developers and the manufacturers of WiBro systems and devices. Their aims were then further extended to gaining technology as well as market leadership for next-generation mobile communications.

However, despite such progress with the technology and the standard for globalization, adoption of actual WiBro services in Korea was lagging far behind original expectations in the market (Yoon et al., 2007). As of June 2007, 12,443 people subscribed from both operators, which was far less than what had been anticipated by KISDI and ETRI as well as the industry[59]. By the end of August 2008, there were 188,000 subscribers for KT, and 3,000 subscribers for SKT. The penetration rate was only 0.4%, whereas the average revenue per user (ARPU) was estimated at USD$10 (Chung, 2008). Being faced with such discontinuity between the domestic and the international markets, stakeholders raised the need to promote the domestic market for WiBro in close relation with the need to bring about sustainable leadership in the global market for Mobile WiMAX (Park and Kim, 2008; TTA, 2008b). The slow take up of WiBro service was especially regarded as an obstacle for manufacturers in keeping pace with the successful landing of their products in foreign markets, whereas the domestic market was regarded as an important reference site because the manufacturers could bring about further sales to their global counterparts:

> There has been a great success in Russia with WiBro. Within 3 months the subscribers counted 200,000. We are trying to see the factors from various points—Country? Telecom operator? Terminal devices? Samsung's involvement in WiBro entailed the very strong intention to better its position compared to other foreign vendors. Samsung has sold around 200,000,000 terminals, among which only 10% were sold in Korea. The domestic market

---

[59] The number of subscribers was expected to reach 4.9 million by 2008, and 9.2 million by 2011. Less optimistic figures were 2.9 million by 2008, and 6.8 million by 2011.

is important regardless of the volume. When we sell in countries abroad, we often get questions like 'it must be a great success in Korea'—We can't say anything about this.

<div align="right">(Head of Dept, Samsung Electronics, 2 September 2009)</div>

Furthermore, the domestic market, as the home ground for the leading manufacturer, was considered to be the ground upon which competencies could be built against foreign products and services. Thus, the 'vitalization of the domestic market' was increasingly called for by the manufacturers and others whose interests had been aligned towards the global diffusion of WiBro systems and devices:

> Vitalising the domestic market for WiBro is very important. The competency and competitiveness of the domestic technology can be achieved by activating [the market]. Foreign business scales are extremely large, so Samsung alone cannot cover them all. In such cases, we also introduce our domestic-vendor collaborators—It is very important to enhance our competitiveness based on the domestic ecosystem.
>
> (Song, vice president, Samsung, Interview at 4[th]WiBro Convergence Service Technology Workshop, 4-5 March, 2010)

However, the domestic market condition did not easily respond to such expectations linked to globalization. The market adoption of WiBro service in the domestic market remained sluggish. Various problems in services were recognized as reasons for the slow adoption of WiBro service in Korean market, which included limited network coverage, limited choices of handsets and terminal devices, lack of outstanding applications, as well as early commercialization of competing services (Kim, 2009c; Yeo and Park, 2010). KCC then contributed various policy measures to tackle the problems that had been identified as the major causes for the low diffusion of WiBro. KCC called for the operators to actively implement their initial plan by reviewing their progress in relation to their implementation plans for WiBro service, submitted at the time of spectrum licensing. By deploying the 'WiBro Activation Plan,' KCC further addressed its plan for additional licensing of WiBro operation

along with its decision to allow VoIP and the use of the prefix number of mobile telephony, '010' (KCC, 2008).

KCC's efforts to promote more active appropriation of WiBro by the operators, however, did not lead to a quick remedy for the problem of 'diffusion lag'. Operators indeed worked to meet their official deployment plan of WiBro under a degree of pressure from the government. The government's firm intention was to achieve the goal of successful diffusion of WiBro services in the domestic market. Since the launch of WiBro service in 2006, network coverage had expanded from the initial six small areas in a few restricted regions in Seoul and the suburbs to the whole of Seoul and 23 major cities including the metropolitan areas, in 2007 (Ahn, 2007). By the end of 2009, KT's WiBro network had been built over all of Seoul and 19 neighboring cities, subways, major highways, hot-spot areas of Kimpo airport, and universities. SKT had built hot spots around 24 areas in Seoul, 23 areas in the suburbs, and 9 areas in other cities (Kim, 2009c). WiBro's network coverage thus expanded, and nationwide coverage was finally achieved by 2011. Yet, this alone did not lead to the success of WiBro service.

Although the government continued to seek additional measures to promote the domestic WiBro service market, rising disputes addressed whether to sustain efforts to promote domestic WiBro services or to concentrate on enlarging markets for Mobile WiMAX abroad (Kim, 2009d; Lee, 2009a). Furthermore, in the report published by the National Assembly Research Service in December 2009 on the current status of WiBro business and future directions, Kim (2009d) recommended that the government revise its strategy and objectives regarding domestic WiBro policy. The recommendation included varying directions for WiBro such as maximising its use for specific needs in limited areas rather than promoting it as a nationwide service, as well as restructuring the telecommunications market to promote competition.

Yet, WiBro service continued to evolve in the South Korean market, along with the sustained efforts of the government to promote WiBro service, as well as the operators' ongoing search for niche services in collaboration with other players.

Indeed, although the initial projections on the future of WiBro uptake in the domestic market turned out to be largely an illusion about new technological offerings, the diffusion at the global level seemed to suggest further hopes in the face of the uncertainties about the future outcome of WiBro.

5.2.4. Summary

In this section, I examined the interactions among diverging interests in the process of appropriating the generic capabilities of an emerging technology to specific WiBro services in the commercial market. First, I observed rising conflicts in attempts to commercialise an emerging global standard in the domestic market of South Korea. For vendors of WiBro systems, globalisation brought about an urgency to implement their systems in the domestic market so as to provide a reference site for further diffusion of their products abroad. The operators, however, were more inclined to reach wide interoperability and compatibility of the standards.

Actual processes leading to commercial deployment of WiBro systems and the services involved further discrepancies: the differing positioning of WiBro by the two operators against the existing mobile networks and the services, and subsequently the differing implementation roadmaps and deployment strategies for the commercial market. This divergence created further mismatches in operators' intentions and commitments and those of the manufacturers, who were involved in the coproduction of WiBro services in the Korean domestic market. Yet, such mismatches were not easily mitigated. The KCC brought various measures to tackle the problem of what was viewed as the 'diffusion lag.' Indeed, the domestic market uptake of WiBro service lagged far behind the anticipated rates of diffusion. Moreover, the issues relating to the gap were further heightened by the increasing sales of WiBro systems in the overseas market by domestic vendors who argued for the urgency of modeling the domestic market as a reference site for successful deployment of commercial WiBro service.

The process leading to the appropriation of the generic vision and capabilities of WiBro thus involved a degree of divergence of interests whose interactions created conflicts and discrepancies towards the coproduction of WiBro service in the South

Korean market. Although efforts were put forth to coordinate varying interests towards the early commercial uptake of WiBro, they were effective only in showcasing the generic technical possibilities of WiBro.

5.3 Trial and error: Towards finding the niche service of WiBro

The purported vision of WiBro services was not easily met while the operators, especially KT, struggled to develop, implement, and make the services available to users, through various ways of collaborating with other market and innovation players. KT had envisioned WiBro service to provide high-speed Internet anywhere, any time, especially while on the move, enjoying high-speed data transfer with low access costs (Ko, 2005). Yet, when KT and SKT officially rolled out commercial WiBro service on 30 June 2006, one type of device was available for the service: PCMCIA for laptops enabled an Internet connection to access web browsers (MIC, 2006c). Although it was anticipated that the major device for WiBro service would eventually be mobile phones including smartphones, major WiBro service seemed to stabilise around wireless Internet access service for laptop users.

In this section I more closely observe the process of appropriation of the generic technology by the operators and others. I demonstrate how the players—especially those committed to deploying WiBro technology and service—struggled to appropriate the technology into workable services. I also discuss how the operator and committed players came to create WiBro as a niche service. Lastly, it explores into the process of appropriation and use during which further innovation took place.

5.3.1. Facing challenges: Mobile phones and network coverage

By 2009, mobile devices such as mobile PCs, PMPs, and smartphones were available using WiBro,[60] in addition to modem-type devices such as PCMCIA cards and USB modems (Kim, 2009a; Lee, 2009b). However, they suffered from low market adoption and none provided 'WiBro-only' service, which would eventually bring about the competency of WiBro as a data-intensive mobile service. WiBro had been expected to provide data-intensive multimedia services over a high-speed

---

[60] WiBro Smartphone (SPH-M8100, WiBro+CDMA)) LG PDA phone(LG-KC1, LG&KT), MITs (SPH-P9000), 'full touch WiBro phone' (SCH-M830, May 2009, SKT).

network with low end-user fees to differentiate WiBro from other mobile services over the existing cellular networks of CDMA and WCDMA (Choi, 2004b; Kim et al., 2006; TTA, 2008b). Various challenges were met in developing and deploying WiBro products and services that required an effective alignment of various choices that were simultaneously operating in existing market structures, consisting of a wide range of telecommunications services including 3G, fixed-line broadband Internet, and broadcasting services (e.g., Digital Mobile Broadcasting).

Among efforts to provide WiBro-embedded mobile phones, for example, KT struggled over the challenges linked to the wide diffusion of 2G and 3G mobile phones. Technical difficulties, mainly due to the limited economies of scale in producing WiBro-embedded mobile phones, precluded achieving the same quality of service as existing mobile services:

> We actually thought we needed a phone type to enter the mass market. At that time voice was on 2G. We developed a 2G+WiBro phone, but it wasn't easy to develop the phone type. There were various technical difficulties and bugs, and insufficient design aspects. There were already 45,000,000 very nice phones on the market. To make our [WiBro] phones as nice as them, we would have to order several hundred thousand or a million phones. But this wasn't possible from the beginning. We did invest a lot in the network but we were a bit passive in investing in terminals. We had only tens of thousands of phones, and as a result, although the size was big, the design was not very nice. The phone got disconnected easily, and the screen would black out. We first provided three types: two from Samsung and one from LG. They were 2G, and at the end of last year we made one more. It was 3W, åincluding WiFi, 3G, and WiBro. But there was no significant market response for that either. We've stopped producing 2G+WiBro phones. We don't plan to produce phones any more. We may be developing phones in the future but for now, phones are difficult to develop. Using common sense, it's really good to have WiFi, 3G, and WiBro on one phone. But if they are included, the size becomes bigger, there is higher power consumption, the battery doesn't last long, software gets entangled inside, and when using an

application, it had to be elaborate as well, and thus difficult technically. It would seem nice to have everything included together, but that is not easy.

(Director at KT, 27 May 2010)

Indeed, while they struggled to compete in the existing mobile data-service market through the advanced mobile phones, WiBro embedded mobile phones were regarded as having low quality of service in mobility, stability, battery life, and security (Kim and Lee, 2008).

The lack of competency and the economies of scale were closely linked to the timely expansion of network coverage. Nationwide network coverage was a critical precondition for early and timely uptake of the generic technical capabilities of WiBro by a wide range of telecommunications-market players including device manufacturers, applications developers, and content service providers (Jang et al., 2005). Yet, by October 2010 only all of Seoul and the major cities in the suburbs, six metropolitan cities, and major highways had been covered by the WiBro network (Seok et al., 2011). The lack of nationwide coverage in the early years of commercial service brought about challenges for expanding the user base, and vice versa. Although operators had made attempts to put mobile applications on a variety of mobile devices, the lack of nationwide coverage and rather slow expansion prevented them from attracting a wider array of device manufacturers and module makers.[61] Furthermore, the preference by the operator itself for the existing 3G network and WiBro could only concentrate the development and deployment of 3G handsets, considering the limited physical coverage of the WiBro network:

> It's quite important to see how the network operators develop terminal
> devices. For example, if terminals that could access 3G, WiFi, and WiBro are
> in general use, that would be best, but in fact, operators proposed
> requirements to terminal manufacturers … such as to develop a terminal that
> can gain access to 3G and WiFi. … But the WiBro network is limited and
> now covers 84 cities, so there are limits to developing WiBro-only terminals

---

[61] Interview, Module maker, and provider : 'For us as module makers and providers, there were many options. Our position is more closely aligned to following the market rather than leading, so if there is large demand, it's worth investing and if it's not we won't.'

and making sales to customers. And then operators chose rather to concentrate on the development and sales of 3G terminals with nationwide coverage, and as a result WiBro could not but fall behind.

<div align="right">(Director, SKT, 13 September 2010)</div>

Around 2008, KT attempted to build an 'ecosystem' to support the wide adoption of WiBro service by forming the 'KT WiBro Alliance' (Hwang, 2008). The alliance was comprised of manufacturers of WiBro chipsets, netbooks, PMPs, navigation, electronic dictionaries, and more. For the content, KT had signed an agreement with Freechal Consortium of which the service providers for fixed-line broadband Internet were members. These alliances and networks of operators, manufacturers, applications developers, and content providers were expected to eventually bring about an ecosystem for WiBro service. However, their commitment to implementing WiBro service did not last long, nor was it effective, as WiBro failed to meet users' needs in the variety of choices of devices as well as the quality of service over the networks (Paik et al., 2009). Although KT had been anxious over data-intensive applications and content such as mobile TV/IPTV, games, multimedia messenger service, and video-streaming services to be the outstanding applications and services for WiBro, these services could not be fully enjoyed by customers due to the limited coverage and the limited lineup of mobile devices.

5.3.2. Finding niche services for WiBro

Over the years of sustained deployment of WiBro services, a few niche areas of WiBro service were generally regarded as the 'success examples' of WiBro (Lee et al., 2011b). Being faced with obstacles that could not be resolved in a short period of time, KT searched for niche service areas where WiBro would eventually build momentum for further diffusion. One was a convergence service using a router to connect WiFi devices (such as iPod Touch, laptops and netbooks, and Nintendo DS) through the WiBro network.[62] This did result in a short rise in the rate of adoption of WiBro service, along with a rise in the sales of small-sized laptops: the 'netbooks.' Together with USB WiBro modems to connect to the Internet, the routers provided

---

[62] Egg, the mobile router for WiFi connection was first introduced by KT in April 2009. Equivalent to KT's Egg, SKT's Bridge came to market in February 2010.

steady sales as a niche service using WiBro (Seok et al., 2011).[63].WiBro service, thus, seemed to stabilize around mobile Internet-access service:

> Just provide Internet access. Even if we develop specific service [for WiBro], it's not competitive against the galaxy of services in the market, and we won't attempt to go further. We did put much effort into phones—phones have their specific services. With the rise of smartphone use, open Internet browsing would become popular, but before smartphones—in feature phones, closed content was used. So we tried hard to develop services, but the phone itself wasn't competitive, and it became meaningless. So, now there is no WiBro-specific service. It's just Internet-access service.
>
> (Director at KT, 27 May 2010)

KT's WiBro service for the mass market was focused on the provision of WiBro USB modems and mobile routers, especially those named 'Egg,' first commercialised through close collaboration with a small- and medium-sized manufacturing company for WiBro devices. From an interview with the chief technical officer of the device manufacturer, the strong coupling of the developer–user relationship was important. The chief technical officer mentioned KT as a key user of their product; KT's preferences and needs were defined and actively reflected in the shaping of their WiBro products:

> Network operators are involved in all telecommunications businesses. Looking at issues like mobile subsidies, it's different from the selling [manufacturer's] viewpoint of products to that of general users. So we thought operators were our users in the first place. Although we were led to end users through collaboration with the operators, the best way is to listen to those people who are really responsible for this business, and share concerns about prospects and so on. Based on this we make decisions.
>
> (CTO at MODACOM, 15 July 2010)

---

[63] By early 2010, the three types of WiBro devices for connecting to the Internet (USB modem, mobile router, and PCMCIA) together accounted for 90% of the market share in WiBro terminals (Seok et al. 2011, 171p).

For Moda, KT was positioned as the responsible user who would actively search for requirements on which the company would build their product. Although the company would also be searching, they could have the best certainty through KT about how their products would be appropriated (Interview with CIO, Moda in 2010). Through the sustained relationship between the manufacturer and KT, the manufacturer was positioned as one of the leading manufacturers among 11 WiBro-device manufacturers by 2011, with the largest domestic market share of WiBro routers (Seok et al., 2011).

Based on the successful debut of WiBro-enabled mobile routers to connect to the Internet, KT extended its service by committing itself to developing business-to-business solutions through the use of the WiBro network. WiBro was increasingly implemented at specific business sites, where it contributed to enhancing the business environment. KT's mobile router, Egg,[64] was implemented in one of the largest private taxi ('call-taxi') companies in Korea, and enhanced their success rates for allocation of their taxis upon customer requests for the taxi service. Egg was connected with the navigation system in each taxi to provide GPS information while it enabled interactive communication with the control center of the company. The sales team for WiBro at KT searched for additional diverse uses of WiBro, especially in business-to-business areas, as they increasingly faced difficulty meeting mass-market needs (Interview, Director at KT, 2010).

5.3.3. Innovation in use: The making of the 'digital shipyard'

KT's further struggle for the appropriation of WiBro met efforts from elsewhere, bringing a massive shipbuilding site into a WiBro zone where the technology was deployed, appropriated, and domesticated. It was a site for innovation through WiBro: several groups of innovation players were fully committed to deploying WiBro infrastructure over the vast area of the shipbuilding site. This niche area consisted of the diverse environment of the shipbuilding sites, covering 5.9 million m^2 where 47,000 employees were engaged (Cheong, 2009). Fixed and wireless communications were critical for the working environment in the shipyard where the

---

[64] Egg, a mobile router for WiFi connection was first developed by Moda Communication, Inc. (http://www.modacom.co.kr)

allocation of huge blocks of ship parts and safety equipment were quite dependent on communications among staff. A worker in the shipyard had to carry multiple terminal devices to communicate: for example, a walky-talky for ordering a crane, a trunked radio system for group-consultations, and a mobile phone.

This niche area needed an advanced ICT infrastructure. ETRI, one of the core developers of the WiBro system, first suggested implementing WiBro[65] in the shipyard. The deployment of WiBro in the shipbuilding environment was thus pursued in close collaboration with ETRI, coordinated through a collaborative programme on advancing the shipbuilding industry towards global excellence, based on IT (Park et al., 2010). KT and Hyundai Heavy Industry (HHI) signed a memorandum of understanding in early 2009 to implement KT's 'W-Office (WiBro-Office)' system, a solution developed by KT to provide high-speed data service for enterprises using WiBro (Kim, 2009b).

Alongside the building of formal relations between key collaborators, there was a strong commitment by the members in HHI. This was regarded by the interviewee from the company as a crucial driver for their high-risk-taking innovative attempt:

> We are internal IT experts. We made the decision to do it. We made the suggestion, and the CIO of this company thought it reasonable. … I think the role of CIO is very important. The CIO has to be the main agent for the convergence, to have the leadership to bring IT to be an innovative tool. … There is great risk in this so the most important part is that decision making must be based on foresight. Then there are followers like us who have the capacity to faithfully carry out the project. … Harmony is necessary.
>
> (Director at HHI, 24 Feb 2010)

The IT operation-management team in the company was thus fully committed to deploying, testing, and further developing WiBro applications and services in the shipbuilding environment. They actively searched and struggled, together with KT and ETRI, to successfully deploy WiBro in places where it could be operated and

---

[65] Interview with Director at HHI.

used most effectively and efficiently. The harmonious efforts to engage WiBro as an innovative infrastructure for their shipbuilding environment resulted in the successful deployment of the technology and the service: innovation took place at the worksites, bringing wireless communication to areas where they had not had even fixed-line communications:

> Inside our drillship—it's very deep inside—up to 30 to 40m—the whole space is surrounded by steel and no communication is possible inside. No fixed-line phones, no walky talkies. It's just a dark underworld. Here we brought communication using WiBro. We put in PLC-power line communication and on top of this we deployed WiBro. The structure is simple. … Nearby, WiFi phones and video phones can be used. Our staff member, Mr. Chung, was testing the phone there and the workers thought he was crazy and told him that phones don't work there. If there is a total shift, it feels strange. Then, we approached them by explaining, and they began to ask for fast deployment. They were eager to use the service.

> (Director at HHI, 24 Feb 2010)

The innovation led to further innovations as WiBro was implemented, tested, and used by IT operators and the shipbuilders. The staff in the IT operation department regarded themselves as internal service providers involved in the sales, marketing, and deployment, while they were fortunate enough to have committed users in the domain of their 'marketplace' (Interview, Director, HHI, 24 Feb 2010). In response to their efforts in the implementation, shipbuilders provided active feedback: they brought additional requests and used WiBro service creatively, bringing about further innovation in the applications and use of WiBro:

> New exploration of applications in the actual workplace are much more active than technical improvements. ... We've given them a set of [Coco] blocks.[66] We built the kiosk as a model for them. The workers are already using it in very many ways—for calibration of the ship's location and a lot more. They develop its use in relation to their own job. WiBro as a

---

[66]A type of children's toy similar to Lego blocks.

technology is quite advanced, and there are more examples of its innovative use than further innovation in the technology itself. We leave the technical part to academia, and we concentrate on the applications—there are uses that we had not even anticipated. Like, we gave them blocks, and they've made a tank.

<div align="right">(Director at HHI, 24 Feb 2010)</div>

WiBro was thus implemented, tested, and used, leading to creative innovation and use in these niche areas, explored through close collaborations among the innovation players based on their strong commitment to developing, deploying, and using WiBro systems and services. In September 2009, the era of the 'digital shipyard' opened, based on the successful implementation of KT's WiBro-enabled infrastructures and services (Chang, 2009).

5.3.4. Summary

In this section, I explicated the process of finding and creating niche WiBro services in the existing telecommunications market. Although the players faced a number of challenges especially in relation to the existing mobile phone market, the struggle to bring about workable commercial WiBro service led to finding a few niche areas.

First, I discussed how the players came to identify major obstacles to successful deployment of commercial WiBro service in the course of appropriating the technology: for example, economies of scale that had been reached by mobile phones, and the large-scale investment needed for nationwide network coverage. Second, I further discussed how the struggle to appropriate WiBro through interactions among the committed players resulted in bringing about niche services including mobile Internet access for laptop users and in business-application areas. Third, I introduced a particular example of successful application and adoption of WiBro in making the digital shipyard, where the collaboration among the committed players in the application field brought about further innovation in the use of WiBro service.

WiBro's niche services, however, did not continue to expand into other areas of use, nor did it succeed in scaling-up to provide convergence services in the mass market,

as had been anticipated. What was thus regarded as an outcome of a large-scale technological innovation did not meet the initial visions and expectations. Despite an ongoing search and deployment efforts, WiBro in the telecommunications market seemed to stabilise as a niche service that would complement existing telecommunications services in limited applications areas. Furthermore, although WiBro was expected to compete against Long-Term Evolution (LTE) in the adoption of 4G standard, the hopes for the 4G WiBro tumbled as the two WiBro operators—KT and SKT—chose to adopt LTE as their next-generation mobile standard. Subsequently, WiBro was largely positioned as a network and infrastructure to support rapidly increasing large-scale data traffic, providing, at best, a complementary role in 4G mobile communications (Yeo and Park, 2010).

5.4 Conclusion

In this chapter, I examined the complex dynamics that shaped WiBro services in South Korea, especially through the process of appropriating the generic vision, technology, and standard by the involved innovation players including the manufacturers, government, operators, and others. Here, the concept of appropriation was adopted from the social-learning framework, where it denotes the process of an innovation being adapted to local circumstances or contexts (van Lieshout et al., 2001; Williams et al., 2005). Although the concept has generally been used in delineating the process of uptake by final users of an innovation, the process of *appropriation* in this research has mainly involved intermediaries: the intermediate users that have taken up the generic vision, technology, and standard of WiBro to produce specific WiBro services for the commercial telecommunications market.

In the first section of this chapter, I explicated the multilevel innovation players as they were simultaneously involved in multiple alignments, carrying differing interests, goals, and strategies in each alignment formed. As the players were led towards appropriating the generic vision of WiBro, their varying concerns and aims, linked to the commercial deployment of an emerging telecommunications service, resulted in forming separate alignments from, yet to an extent concurrently with, the initially coordinated alignments for the shaping of the generic vision, technology, and standard for WiBro service. Although the separate alignments reflected differing

concerns and strategies towards the commercial uptake of WiBro, they were reconfigured in response to the choice of a single standard through the standardisation of WiBro. Yet, although the reconfiguration seemed to reflect a degree of closure in choosing a single standard for WiBro, the visions and aims for appropriating the single standard by the operators still diverged to a degree, especially competing against each other to claim their own eligibility and competency for getting the license for the spectrum resource.

In the second section, I focused on the discrepancies that arose in the course of bringing about commercial WiBro service in the domestic market. Due to the globalisation of what had initially been the domestic standard, the interests and urgency for adopting the global standard in the domestic market differed between the manufacturers and the operators: the manufacturers aimed for early commercial deployment to secure their technology leadership whereas the operators aimed to secure wider interoperability prior to early commercialisation. Alongside such conflicts, the technical performance of WiBro systems and the feasibility of WiBro enabled mobile multimedia services to successfully demonstrate WiBro to international participants at the APEC meeting in Seoul, Korea under the coordination by MIC for seamless cooperation among the manufacturers, operators, and others. Despite the successful demonstrations of the generic performance of the most advanced mobile multimedia services, players faced further discrepancies due to diverging choices towards the appropriation of the standard for actual commercial WiBro service. As choices diverged, outcomes diverged from the initial visions and expectations, leading to disputes about continuing to promote commercial WiBro service in the Korean domestic market.

In the third section, I further observed the process of appropriating and using the generic technological offerings and the service by the players that were, to a degree, committed to the coproduction of WiBro service in the domestic market. The process involved trial and error through the challenges the players faced as they attempted to bring about WiBro service in the telecommunications market. They faced a number of obstacles including the lack of reaching economies of scale of WiBro devices due to the already abudant mobile phones in the market, as well as the lack of network

coverage due to the huge investments required. As they continued to search for niche areas for WiBro service, they identified and created the niche for WiBro providing mobile Internet access to end users through USB modems and mobile routers. They also provided an advanced, yet cost-efficient infrastructure for the business environment, which was identified as a successful niche area for WiBro service. In these niche areas, one could observe further innovation taking place through the process of final appropriation and use.

This chapter thus highlighted the complexities of the innovation process, involving the development and deployment of the generic vision, technology, and standard for an emerging telecommunications service. It has especially demonstrated the diverging interests, visions, and choices on appropriating the generic technical capabilities of WiBro, which resulted in outcomes that diverged from the initial visions and expectations. Yet, over the evolution of WiBro service in the Korean domestic market and beyond, complexity alone does not explain the process of technological innovation and change. In the following chapter, I continue to discuss changing contingencies in the process of innovation, and how they have been addressed by the innovation players involved in the shaping of WiBro service.

Chapter 6. Dealing with changing contingencies: The dynamics towards the evolution of WiBro

6.0 Introduction

Over the years of deployment and use of WiBro service in the domestic market of South Korea, many critiques focused on addressing the gap that arose between initial expectations and the actual take-up of WiBro and have suggested subsequent measures to overcome the gap (Joo, 2007b; Kim, 2009d; Paik et al., 2009; Park, 2008). However, by focusing on the changing contingencies in the process of shaping WiBro services, this chapter brings the discussion beyond the scope of addressing the gap. Rather, I explicate the gap by addressing the shifts and changes in the choices of innovation players involved in the process of appropriating the generic technical capabilities of WiBro into specific services. I therefore examine changing contingencies in the shaping of WiBro service, as well as how those contingencies have been addressed.

In the first section, I discuss the evolving dynamics of mobile telecommunications along which WiBro did not evolve as had been expected. As mobile-communications technologies evolved towards 4G (fourth-generation) mobile-communications standards, and as the use of mobile data surged with the introduction of smartphones, WiBro was further expected to evolve towards 4G mobile service. However, WiBro did not evolve to provide advanced mobile data service, but remained a niche service in the telecommunications market.

In the second section, I examine shifting choices of key players in the course of deployment of WiBro, which contributed to bringing about outcomes that diverged from the initial visions and expectations of commercial WiBro service. The choices that have shifted include the choice of VoIP as an outstanding application of WiBro, as well as the choice of LTE by global operators of WiMAX and others towards fourth-generation mobile-communications services.

In the third section, I bring the discussion to the controversy in South Korea around policy choice with regard to the deployment, use, and future direction of WiBro. The

controversy resulted in the reshaping of the generic vision of WiBro, as well as recent WiBro policy in Korea.

Last, I conclude with a discussion of the observed changing contingencies that have accompanied the shifting choices of varying interests in the evolution of WiBro in the telecommunications market.

6.1 Evolving dynamics in mobile telecommunications

The choices surrounding the deployment of WiBro technology were shaped through trial and error by more or less committed players, as they struggled to appropriate the generic capabilities of WiBro into specific services in the existing and evolving telecommunications market. However, their choices were further shaped not only by their histories, experiences and learning through the process of appropriation, but also through interactions with evolving technologies, services, and industry in the telecommunications market. Technologies, including IEEE802.16e for WiBro and WCDMA for 3G mobile communication, evolved to next-generation mobile-communications technologies, namely, the 4G. The rapid diffusion of smartphones led by the innovation of iPhone brought about a steep rise in the use of mobile data services on the existing yet evolving cellular network and infrastructure. Also, industries were merging and government organisations were restructuring, headed towards the converging market for fixed and mobile, as well as telecommunications and broadcasting services.

The evolving dynamics of telecommunications technologies and services were both an opportunity and threat for the evolution of WiBro services. By 2009, the WiBro technology, IEEE802.16e, had been acknowledged as 3G mobile communications technology by the International Telecommunications Union (ITU), while it further evolved to IEEE802.16m, which was proposed for global 4G mobile wireless broadband technology known as IMT-Advanced,[67] along with 3GPP LTE Release 10

---

[67] ITU announced the next-generation of standards for global wireless broadband communications as 'IMT-Advanced': ITU defined IMT-Advanced systems to provide access to 'a wide range of telecommunication services supported by mobile and fixed networks, which are increasingly packet-based'. The new capabilities were to go beyond IMT-2000 while targeting transmission rates of 100 Mbit/s in a high-mobility environment,

and beyond (LTE-Advanced) (ITU, 2009). The two technologies were by then largely regarded as competing standards for 4G, whereas the Korean government officially chose to support and promote both technologies, as the proposals to ITU were carried out by international communities[68].

As the Korea Communications Commission (KCC) officially opted for both standards to be implemented in the domestic market, this brought about a dilemma, especially with regard to how to appropriate both technologies in the domestic market, on the verge of what was increasingly seen as the "'4G War'. At the same time, one of the key rising visions and rationale for accommodating both standards suggested that the domestic market be built as a 'global mobile testbed' [69]:

> The 4G war has begun at the verge of opening up WiBro. One of the leading LTE players, Ericsson, is building a bridgehead in Korea. … It intends to challenge the WiBro birthplace. … At this stage, how are we going to advance WiBro while at the same time accepting LTE. We shall not be closed [against such a challenge]. We should accept it. Yet, we need a strategy, such as controlling the time of release, etc. I believe we need to be the global mobile testbed by being successful with WiBro as well as adopting the 4G [LTE] technology. New services shall find a way out by being tested in our nation. We shall then be the central nation for 4G mobile communications, create national wealth, and export our products.
>
>   (Speech by Lee BK, KCC, at 4G Commmunication Symposium, 29 October 2009)

In line with such a vision, it was deemed critical to vitalize the WiBro service in the domestic market to realise the vision for 4G. It was expected WiBro would evolve towards 4G through various business models springing from the existing mobile

---

and 1Gbit/s in a stationary environment.
(http://www.itu.int/net/newsroom/wrc/2012/reports/imt_advanced.aspx)
[68] Both technologies, under the names of WirelessMAN-Advanced and LTE-Advanced, were officially designated as IMT-Advanced by the ITU in January 2012 ITU, 2012, IMT-Advanced standards announced for next-generation mobile technology..
[69] Lee Byung-Gi, Speech at 4G Communications, October 2009 (recorded and transcribed by the author).

telephony. KCC was therefore keen to vitalize WiBro service, and devised a WiBro vitalization policy with three policy directions and eight projects in November 2009 (KCC, 2011a). It aimed to 1) create an environment for competition among the operators, 2) construct effective nationwide network coverage, and 3) improve WiBro business. Various measures were prepared to meet these directions under the frame of eight policy projects, which included changing network bandwidth from 8.75MHz to 10MHz to secure interoperability with global Mobile WiMAX service, providing an environment for entrance of a new operator as well as adoption of mobile virtual network operator (MVNO). KCC also planned to implement strong measures to bring about nationwide coverage of WiBro networks by applying rigorous review to operators' progress against the initial plans that had been acknowledged through licensing (KCC, 2011a). To advance WiBro business plans, KCC was to provide a favorable environment for various types of convergence services to be brought forth through WiBro, including the interoperable service of WiBro/WCDMA/Wifi, mobile VoIP and mobile IPTV service.

However, not all these plans proved to be viable nor effective in the short run. Despite several attempts to allocate an additional license for WiBro, KT and SKT has remained the only licensees to WiBro in the 2.3GHz frequency band to date. The goal of nationwide coverage was reached only to the extent of fulfilling the role of mobile hot-spots. Operators were still faced with the challenges of low demand for mobile data services: while WiBro had been intended to introduce data-intensive services in the market, thereby bringing about services differentiated from the existing mobile telephony, it was further diagnosed, and increasingly regarded by many that WiBro, as an advanced physical infrastructure, could not alone bring about the rise of demand for mobile data services (KCC, 2011a, b).

The demand for the mobile Internet, however, finally arose rather rapidly with the introduction of the iPhone in 2009 and the successive adoption of smartphones, implemented through the existing 3G mobile network. In Korea, the mobile data traffic increased from 409TB to 10,132TB during the period between December

2009 and June 2011 (Lee et al., 2011a, 37p).[70] Such an increase in the mobile data traffic was spurred by the rapid uptake of smartphones,[71] of which the increase rate was 35.8% between 2009 and 2011(Moon et al., 2011, 53p). The rise in mobile-service use and the subsequent surge in mobile data traffic also brought about renewed expectations that they would drive the growth of WiBro services in the domestic market (Seok et al., 2011). There was indeed an increase in the number of subscribers to WiBro service during the period of wide adoption of smartphones including the iPhone.

However, WiBro service was still limited to the use of mobile routers to connect to wireless Internet. The rise of mobile data-service use in the telecommunications market did not bring about rapid uptake of WiBro either, despite the hopeful anticipation by many that a high rise in mobile-data use would eventually bring about the adoption of WiBro. For some, the choice of WiBro had already shifted to seeking other opportunities to advance to next-generation communications.

In the next section, I observe some key shifts in the choices for appropriating WiBro. These choices further shaped WiBro services, yet diverged from the initial plans and visions.

6.2 Shifting choices: Towards the evolution of mobile services and standards

As for WiBro, there was no outstanding application to drive the use of WiBro beyond simple Internet-access service. Indeed, mobile VoIP had long been considered the outstanding application for WiBro, and the KCC had finally allowed VoIP using WiBro for commercial deployment in December 2008 (KCC, 2008). They had also allowed use of the same prefix number—'010'—for existing mobile telephony. Yet, such a radical decision in the regulatory framework did not bring about much turbulence in the market for mobile telecommunications. Whether to adopt VoIP as an outstanding application on WiBro was left to the two operators that

---

[70]Moon et al. 2011 A Study on the Structure of Smart Ecosystem and the Regulatory Framework, 54p; Lee et al 2011, 37p.
[71]Smartphones rapidly diffused in Korea with the introduction of the iPhone through KT in November 2009. As of 1 May 2012, half of Korea's mobile users owned a smartphone: some 26.72 million people used mobile of a total of 52.55 million. (http://www.telecompaper.com/news/smartphone-penetration-hits-50-in-korea--873176)

owned the cellular voice and WiBro networks. Yet, neither of the operators implemented the VoIP service using their WiBro network, as this could be a threat to their own existing mobile telephony service over the CDMA and WCDMA/HSDPA networks (Kim and Hwang, 2009).

Indeed, KT's vision and the actual positioning of WiBro service had undergone a significant change, especially since its merger with KTF, the mobile subsidiary of KT, in 2009. Although KT had long insisted that VoIP on WiBro should be allowed with the prefix number for the mobile phone service, 010, its merger with the second largest mobile operator in Korea had ensured a radical shift in their view of the relationship between the two networks:

> From KT's viewpoint, there was no need for WiBro voice. There had been, before the merger with KTF. At first, we had pursued a triple-play concept that would enable voice with video, broadcasting, and Internet. … For HSDPA, a subset technology to WCDMA , voice is the key. It has nationwide coverage. However, the capacity falls short for data [service]. … WiBro is data-service centered. Coverage focuses on big cities. It planned to expand, also considering expansion with a focus on the big cities. Apart from those places, the usage is not heavy, and therefore HSDPA can be used. For users, technology is not important. The vertical handover between different networks is possible.
>
> (Director at KT, 16 October 2009)

KT had thus come up with a strategy of positioning HSDPA for voice and WiBro for data. By 2010, WiBro was evolving in close relationship with the evolving communications standards from 3G to 4G (KISDI, 2011). Yet, the physical infrastructures and the services of WiBro were increasingly positioned as complementary to the existing yet evolving mobile standard towards LTE. Especially with the limited network coverage areas of WiBro, WiBro could not alone compete as a reliable mobile communications service against the existing mobile telephony. Rather, KT decided WiBro could play a competent role in distributing mobile-data traffic:

The relationship [between WiBro and LTE] may as well be seen as complementary. An operator that does not choose WiBro can just make its way towards 4G-LTE following the evolutionary map of mobile communications. KT should go towards LTE. But it also operates the WiBro network. … But the purpose of WiBro is not voice communication. Wireless [mobile] data communications … were initially born for data. The purpose of the mobile-communications network has been voice. So the technical characteristics differ. … However, KT has to invest over one trillion Korean Won to build all the networks for such coverage, and yet it also has to go for LTE, so this requires setting up the relationship. 4G has complete coverage: it can be used in the toilet, and it can be used on the peak of the mountain. So mobile broadband has to diffuse through 4G. Although WiBro covers Seoul, it doesn't work at higher levels inside buildings and skyscrapers. ... So it is inconvenient. But we couldn't invest more to build the network like the voice network. But [WiBro's] network capacity is far better than that of the voice network.[72] Eventually the market for mobile broadband will open up, people will use smartphones, and 4G alone cannot manage the huge increase in the traffic. So KT could use WiBro as a complementary network.

(Director at KT, 27 May 2010)

Indeed, the evolution of the two differing standards—WiBro (IEEE802.16e) and HSDPA—towards 4G, brought about dilemmas for a single operator in having to invest in and operate both networks. Meanwhile, KT and SKT, as carriers of both networks, clearly chose their evolutionary path towards LTE (Lee, 2011) as the next-generation mobile standard. In fact, a number of operators made the same choice around the globe, increasingly opting for LTE as their evolutionary path. The competition at the standards level suggested that ultimately, LTE would be the dominant 4G mobile network and service. Global market research such as that performed by Ovum, also projected the ratio of the markets for LTE and mobile WiMAX to be 82.9:17.1[73] in subscriber rates. Meanwhile, the WiMAX market faced

---

[72] "Voice network" was often used to describe the 2G and 3G (HSDPA) network in relation to the WiBro network.
[73] OVUM (2011) from Kim (2012), 76p.

increasing shifts by WiMAX operators around the world, as they opted for LTE services to replace existing WiMAX service in their continuing transition to 4G (Jang, 2013).
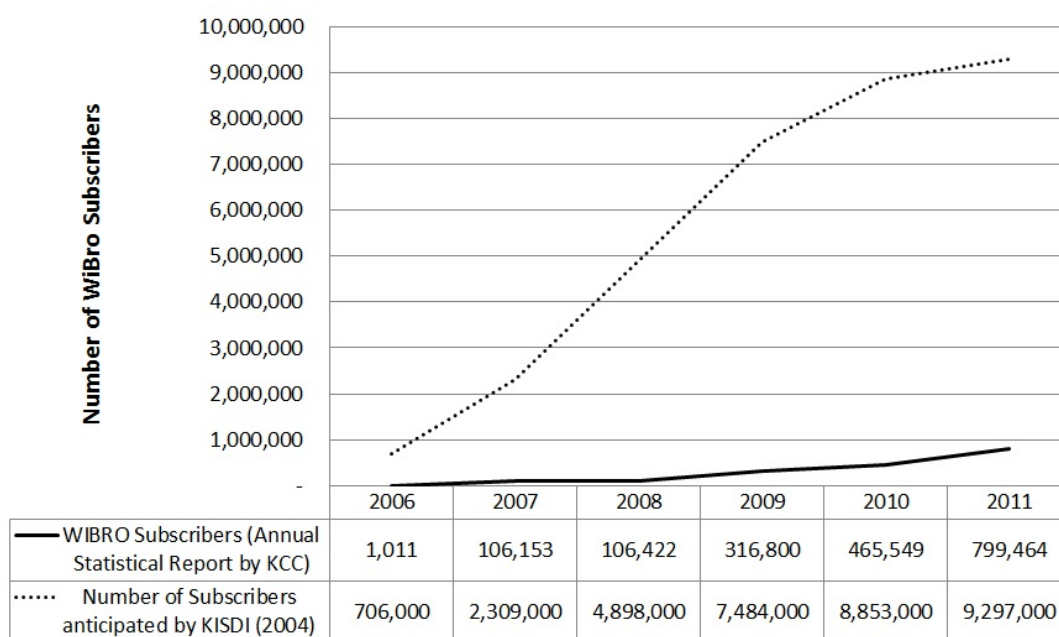
Along the shifting choices by global players towards 4G-LTE, the government institute for telecommunications policy in Korea, through a report on the Promotion Policy of WiBro Services in the Korean Mobile Market, suggested the need to reposition WiBro at the level of domestic policy (KCC, 2011a). They expected the sustained market for WiBro would continue to exist, considering its high-speed data-transfer capability based on broadband technology. Therefore, they recommended a focus on emerging economies, where fixed-line Internet had not been fully implemented. Furthermore, LTE was regarded as a model for voice/data service integrated with 3G, whereas an adequate business model for WiBro was considered to be datacentric mobile Internet services linked to smart grids and machine-to-machine communications. Thus, the report was, to a degree, urging for reshaping the generic vision of WiBro, which had initially been shaped through the reallocation of the 2.3Ghz frequency band as early as 2002.

Yet, additional controversies arose with regard to the sustenance of WiBro, as the expiration date of the licenses in the 2.3GHz frequency band was approaching. The next section discusses these controversies that were closely linked with policy decisions about spectrum licensing. That process entailed reflecting on the past performance of WiBro service, its current positioning, as well as future outlooks and strategies of the players involved in the shaping of WiBro service.

6.3 The controversy: Towards reshaping of WiBro policy

By the year 2011, nearly a decade had passed since the reallocation of the 2.3GHz frequency band for Portable Internet use, and five years since the launching of the commercial WiBro service took place. Yet, the WiBro market was still facing a significant gap between the initial visions and the actual adoption of the service. The gap was recognized in the number of subscribers, and in the actual service products and use in the market. WiBro had initially been expected to carry data intensive mobile multimedia services, anticipated to reach 8.5 to 10.5 million subscribers, with

sales reaching up to 7 trillion KRW by 2010 (MIC, 2004b). However, the resulting

phase of WiBro subscribers and sales after five years of the initial launch of the

commercial service only brought about deepening concerns about the viability of

WiBro service in the evolving telecommunications market. By November 2011, the

total subscribers to WiBro amounted to 799,464 (KCC, 2011c) in stark contrast to

the anticipated number of 9,297,000 by the year 2012 (TTA, 2006).

	2006	2007	2008	2009	2010	2011
WIBRO Subscribers (Annual Statistical Report by KCC)	1,011	106,153	106,422	316,800	465,549	799,464
Number of Subscribers anticipated by KISDI (2004)	706,000	2,309,000	4,898,000	7,484,000	8,853,000	9,297,000

Figure 4 The gap between anticipated number of WiBro subscribers and actual
increase in the subscribers (2006-2011)*
Note. * Original graph **has been adopted and modified** from A Study on Policies
for the Activation of WiBro Market: Korea System Dynamics Research, by Y. S.
Lee, J. R. Chung, S. H. Park, & S. W. Kim, 2011, v. 12, pp. 37–67.

Whilst the policy was still being prepared with an aim to boost the sales for WiBro

service, concerns rose about the need to reposition the direction of WiBro policy,

especially in relation to the nearing of the expiration date and the subsequent need

for a decision about the renewal of the spectrum licenses for WiBro.[74] KCC's

---

[74] Spectrum licenses were initially allocated to KT and SKT in April 2005 for 7 years. The
first phase of use was thus to expire by March 2012. Under Clause 1, Article 16 of the Radio
Waves Act and Article 18 of the Rules on Enforcement of RWA, the applications for
renewal of the licenses were to be made no later than 6 months before the expiration date.
KT and SKT were thus expected to apply for the renewal by 28 September 2011, whereas
the policies related to the renewal, including spectrum renewal pricing, had to be completed
before that date (KCC 2011b).

decision about the renewal of spectrum licenses was closely linked to how current progress in the development and implementation of WiBro services would be assessed and directed in the future. Considering the low diffusion of WiBro services and the deviation from its main use, delineated in the original plan for WiBro service, it was much debated whether the spectrum should be renewed for undifferentiated use by the two operators or be refarmed[75] (KCC, 2011b).

By 2011, KT and SKT had firmly taken evolutionary paths for their mobile services to follow LTE, in line with the major operators in the global telecommunications market that were increasingly opting for 4G LTE. Along such evolving choices, WiBro was repositioned in the market to play the role of a complementary service to 4G LTE, mainly for the distribution of rising data traffic (Kwak et al., 2011). In particular, KT stressed the need to bring WiBro as a tool to adequately respond to the explosion of mobile data traffic, which was expected with the further implementation of LTE (Hearing in 4G Mobile Conference, 27 September 2011). KT's strategy to implement 4G service thus included bringing together LTE and WiBro to provide 4G service to customers with low cost mobile data access. SKT's implementation of WiBro service in number of subscribers and the network coverage area had been far below what KT had accomplished, with sales at 17% of the total sales of WiBro service during 2010 and 2011 (KCC, 2011b). Yet, KT and SKT both applied for the renewal of their licenses whilst insisting that the assessment criteria for their use of the spectrum be extended to consider the current role of WiBro as a complementary service network.

Meanwhile, KCC aimed to produce a policy to bring about further diffusion of WiBro service with the introduction of a fourth mobile operator. By bringing in a fourth mobile operator, in addition to KT, SKT and LGT, the overall intention was to induce competition in the mobile-communications market and thereby lower the cost of mobile services. KCC's intention to introduce the fourth operator was indeed

---

[75] Refarming: "Reassigning government-regulated electromagnetic spectrum for services with higher value. The users of the existing spectrum are forced out, although they may be compensated in some manner. The frequency bands are assigned to communications services that yield greater economic or social benefit."
(http://encyclopedia2.thefreedictionary.com/refarming)

closely linked to its aim of promoting the coevolution of WiBro and LTE (KCC, 2011b). LTE was already being rapidly implemented throughout the country by the three incumbent mobile operators, and it was expected that the fourth mobile operator would operate a WiBro network through the licensing of the WiBro spectrum. WiBro service would then eventually be implemented with voice service through mobile VoIP (m-VoIP).

To realize such a plan, KCC had to prepare policy tools, including a policy to initiate roaming between existing 2G or 3G networks and the WiBro network, as well as to introduce MVNO. In response to such policy-level changes, a consortium was formed named the Korea Mobile Internet (KMI), through the participation of industry players[76]. KMI applied for a WiBro license in June 2010, whereas the eligibility and capability to become a telecommunications operator were to be assessed by a judging committee composed of experts from varying fields including law, economics, finance, and technology. However, KMI failed to obtain a license for WiBro and enter the telecommunications market as the fourth mobile operator[77] (Yoon, 2011). The plans submitted by the consortium were assessed and diagnosed as not meeting the minimum requirements to secure the license, whereas the business plan seemed to be based too much on optimism and the level of funding seemed insecure to carry out the large-scale investment.[78] Following failure to license the fourth mobile operator, KCC had to choose one of three policy options: renewal, nonrenewal, or refarming of the spectrum in the 2.3GHz frequency band.

On 16 March 2012, KCC announced the approval of spectrum-license renewal for KT and SKT (KCC, 2012). This confirmed the changes in the generic vision of WiBro that had guided WiBro policy since its inception. The generic vision of WiBro was indeed reshaped by accommodating the differences and changes. At the policy level, the WiBro promotion policy shifted to advancing WiBro in a

---

[76] Industry players in KMI included DVS Korea, Stem Science, Jaty Electronic, Cmotech, C&S Asset Management. (http://www.telecompaper.com/news/kmi-sees-wibro-licensing-process-delayed--760325)
[77] http://www.koreaherald.com/view.php?ud=20111216000637
[78] KMI had its third attempt in the same year its second application was rejected, in 2011. Internet Space Time's (IST) first application was also rejected along with the third time application by KMI.

complementary relationship to 3G, evolving to 4G LTE. The plan to promote WiBro thus included the construction of wider service coverage around the areas with a large floating population, such as subways and highways, as well as deploying mobile public routers in cities and intercity buses. KCC would also promote price plans to couple WiBro with 3G and LTE as well as WiBro independent service to enable low cost, large-scale data service. WiBro was redefined as being data centered, but the major mobile devices were to be laptops, tablet PCs, and mobile routers.

Yet, the controversy around the use of the spectrum for WiBro did not end with KCC's final decision upon renewal of the WiBro licenses to KT and SKT. To some, the policy repositioning of WiBro as a data-service network was considered affirmation of the failure of WiBro policy. Rising voices argued for reallocating the WiBro spectrum for other uses, in particular Time-Division Long-Term Evolution (TD-LTE)[79], as there were increasing numbers of global operators of WiMAX that were opting to shift to TD-LTE for their mobile communications service (WiMAXForum, 2012). TD-LTE, or LTE TDD was one of the two variants of the 3rd-generational partnership project (3GPP) LTE technology which had been acknowledged as the standard for LTE along with LTE-frequency division duplexing (FDD), the two being differing versions of LTE. The global alliance of TD-LTE was expanding as global operators and system and terminal manufacturers joined to implement the technology (Ayvazian, 2013; Samsung Electronics Co., 2012). The debate about shifting use of the spectrum from WiBro to TD-LTE was further heightened as KT officially remarked about the need for the policy to allow the 2.3GHz frequency band be used for TD-LTE in a timely manner (Lee, 2012).

Although KCC firmly opposed KT's intention to opt for TD-LTE, along with others, towards such a shift, much criticism fell upon the government's inflexibility against the fast-evolving technological landscape. Critics also alluded to Japan's 'Galapagos Effect' which was often used to explain Japan being isolated, due to its unique

---

[79] Abbreviation for Time-Division Duplex LTE vary: TD-LTE, TDD LTE or LTE TDD. TD-LTE is one of the two versions of Long Term Evolution (LTE). In this research, I have used the abbreviations interchangeably by following the usage in original documents referenced.

technological advancement, from the rest of the world (Chung, 2012). In parallel with such criticisms and concerns, modest attempts arose from the government sector, as KISDI the government policy institute for ICT, published a report suggesting the need to review WiBro spectrum policy (Yeo, 2012). The report pointed to the global trend of WiMAX being positioned as complementary to LTE, and argued it was necessary to review current use of the spectrum for WiBro for purposes such as TD-LTE. The report on 'The next generation mobile communications network and spectrum policy direction' warned, however, that a radical turn to TD-LTE carried the risk of following the trail of WiBro, as there were also uncertainties inherent to the ultimate expansion and evolution of TD-LTE.

Such policy-level discussions and debates on the use of WiBro in the 2.3GHz frequency band and on the subsequent need for a shift to TD-LTE called for reflection on past choices in policy decision making as much as it required better choices for the future. Such concerns were reflected in a comment by one of the interviewees:

> Not just to criticize and argue about what had been wrong; policy can be wrongly made. But in order to carry out the next stage, we need to have an accurate review of what had been the problems.
>
> (Head of Department at NARS, 21 December 2012)

Although there seemed to be a resonant view of problematising the current state of WiBro in relation to how the WiBro *should have been*, the comment also seemed to urge a reflective choice on future policy making.

Whilst the shift from WiBro/WiMAX to TD-LTE increasingly seemed to be the global trends of market players, such a shift at the domestic level required a reframing of WiBro policy using hindsight; to amend the choices in relation to the present reflections on the past and the future. Another report by KISDI on market trends and the future direction of WiBro suggested additional changes to WiBro policy in relation to the growing LTE market (Kim, 2012). First, the report recommended that a strategic shift to TD-LTE be considered to adapt to evolving global market trends. Second, sustained advancement of WiBro could be sought

through niche markets such as special-purpose networks (e.g., emergency networks and machine-to-machine communications) and as a substitute network for 3G in developing countries. Third, early introduction of WiBro-Advanced (802.16m) through the fourth mobile operator would be considered a way to pursue further technological competency for future adoption of LTE-Advanced.

In October 2013, the Ministry of Science, ICT and Future Planning (MSIP)[80] announced a plan to allocate spectrum in the 2.5GHz frequency band for either WiBro or LTE TDD, whichever was chosen by the new operator (MSIP, 2013a). Existing licensees of WiBro were not allowed to shift their services to LTE TDD. However, WiBro policy was extended to include the 2.5GHz frequency band under consideration, which was a frequency band used more widely for mobile WiMAX service around the world (KCC, 2011b). The 2.5GHz frequency band was to be licensed to a new telecommunications operator that would have the choice about the technology to be used, between WiBro and LTE TDD (MSIP, 2013a). A focus on TDD-related innovations was firmly sustained in WiBro policy as TDD had been one of the key technical features of WiBro since the initial conceptualisation of the technological innovation. The policy further stated the plan to support and promote the development of TDD-related core technologies, next-generation TDD systems and devices, and applications services to advance TDD technologies and enhance national competitiveness (MSIP, 2013a).

WiBro policy was thus reshaped as it incorporated changing contingencies, especially reflecting on past choices, current dynamics, and future uncertainties. The legacy of TDD-based technological innovation was to continue through the development and deployment of either WiBro or LTE TDD.[81] Alignment with a wider array of global players was sought by allocating the 2.5 GHz frequency band

---

[80] Ministry of Science, ICT, and Future Planning was established on 23 March 2013, succeeding the role of the previous Ministry of Education and Science Technology (MEST) while integrating certain roles of the Korea Communications Commission (KCC) and the previous Ministry of Knowledge Economy. The restructuring of the government organisation took place in line with the administration, led by the newly elected President, Park Geun-Hye on 25 February 2013.
[81] WiBro utilises a Time-Division Duplexing (TDD) scheme, and the technical similarities between WiBro(WiMAX) and LTE have been widely acknowledged in the field.

for the adoption of either the WiBro or the LTE TDD standard. The Korean government had initially opted for two pathways to 4G—LTE-advanced and WirelessMAN-Advanced—at the verge of ITU's standardisation of IMT-Advanced for next-generation global wireless broadband communications. The government further sought to open up the domestic market for an additional version of LTE to evolve and compete for 4G mobile service and beyond.

The controversy around past choices shaping WiBro, current dynamics, and future uncertainties thus brought WiBro policy to be reshaped to accommodate changing contingencies of evolving technologies, services, and human choices towards the coevolution of the spectrum resource, technology, and the standard.

6.4 Conclusion

In this chapter, I have focused on the shifting choices that responded to and constituted the changing contingencies in the mobile-telecommunications market in South Korea and beyond. Along the evolving mobile-communications standards and services, WiBro did not evolve as had been anticipated. Rather, human choices played a crucial role in the evolution of WiBro services. The choices shifted in relation to evolving mobile technologies and services, and the shifting choices led to further divergence of the outcomes from the initial plans and visions. Such divergence then brought about a societal controversy around past choices for WiBro, the current market performance of WiBro, and future directions for WiBro, and to what degree uncertainty loomed.

In the first section, I examined evolving mobile technologies and standards, as well as mobile services that further brought about expectations and efforts to promote WiBro services. However, WiBro did not evolve as had been expected, despite ongoing efforts to bring the service to eventually take off in the evolving telecommunications market, as had been envisioned in the past.

Second, I observed shifting choices that played a crucial role in the shaping of WiBro services; especially in the course of appropriating generic capabilities of

WiBro, as well as towards the future evolution of mobile communications. Despite the regulatory decision to allow VoIP for WiBro service, none of the operators chose to deliver voice-over WiBro. No need existed for voice-over WiBro as KT merged with KTF, the second-largest mobile operator in Korea. Furthermore, KT and SKT, the two operators of WiBro, both chose LTE and WiMAX for their evolution of mobile networks towards 4G. WiBro was thus repositioned as a datacentric service for mobile communications, expected to play a complementary role to the existing mobile network and service that were evolving to 4G LTE, which largely deviated from the initial positioning and envisioning of WiBro in relation to existing and evolving telecommunications services.

Third, I discussed the controversy that resulted from the significant gap between the initial visions and expectations of WiBro and actual outcomes. As the expiration date for the spectrum allocated to WiBro approached, a controversy arose with regard to further use of the spectrum frequency. It was much disputed whether to renew licenses with the same operators for the same use, or to reframe licenses for other uses, especially reflected in past choices, current performance, and the future uncertainties around WiBro. KCC, however, decided to renew the spectrum licenses, accompanied by the reshaping of the generic vision of WiBro. Yet, further controversy arose as KT insisted on the need to shift the use of the spectrum from WiBro to TD-LTE, which was another emerging standard for 4G with growing alignments with interests around the world. The recent decision by the government was finally made to accommodate the changing contingencies of evolving technologies, services, and human choices that continued to shape the coevolution of the spectrum, technology, and standard towards next-generation mobile communications.

Chapter 7. Discussion

7.1 Introduction

In this thesis, I have explicated the story of WiBro in South Korea from its birth to its commercial uptake, and the evolution of the surrounding technology and services. Based on the research framework introduced in Chapter 3, I made in-depth observations from the initial stages of the technological design and development to the commercial uptake. This research has been a contemporary yet longitudinal study of a technological innovation. This single longitudinal case study, based on the social shaping of the technology has taken into account processes linked to the innovation that emerged as early as 2001. The primary focus of this study has been on the gap that emerged during the innovation process between the initial visions and actual outcomes of technology adoption and use. The gap thus represented the complex processes of innovation involving various choices in design, development, and use (MacKenzie and Wajcman, 1999; Williams and Edge, 1996; Williams et al., 2005). Yet, the technology is still evolving, and the services based on the technology are still in use. Through this research, I have addressed the complexities and uncertainties of technological innovation, especially in relation to how to manage the inherent diversity of choices and changing contingencies in the shaping of a large-scale infrastructural technological innovation.

In this chapter, I discuss the general findings based on a longitudinal case study of WiBro in which I examined the lifecycle of an innovation that began in 2001 and is still evolving. I delineate the findings by linking them with the research questions raised in Chapter 1 of this thesis, leading to a brief discussion of the mode of governance of technological innovation and change suggested based on the findings from this research.

7.2 General Discussion

In Chapter 2, the literature review, I defined the research problems in relation to various attempts to address opportunities and uncertainties of technological innovation. Attempts to drive technological innovation in a certain direction are

often found to take place at various levels - of firms' organisations, communities, societies, and nation states. Particular aims and visions often become the initial driving forces to bring about technological innovation. However, despite the projections and strong visions that drive technological innovation, actual outcomes often diverge from the initial visions and anticipations. Studies in STS have particularly addressed these issues by scrutinising the process of technological innovation, the choices of various players involved and the interactions beween them that shape technologies (Russell and Williams, 2002; Williams and Edge, 1996; Williams et al., 2005). The studies have highlighted the complexity of interaction and challenges arising in the attempts to incorporate the visions and aims into actual use. I particularly observed contingencies during technology uptake which in turn generated further uncertainties about the future.

By undertaking a contemporary case study of WiBro I was able to examine processes that did not necessarily link to a known or prefigured result or outcome, as would be the case in a retrospective examination of a technological change. I observed the interactions among the players and their choices in the course of a search for an unknown future. Much of the process under study reflected coherent relations from the outset, and I observed the process by applying the concept of an *arena* to bring an integrated view of dispersed processes that came to be linked to an innovation process over time: the term *arena* was adapted from the concept of '*development arena*' (Jorgensen and Sorensen, 1999; Jørgensen and Sørensen, 2002). In Jørgensen and Sørensen's (1999) conceptualisation, the development arena denoted a space to analyze and describe processes in the making: the processes of "becoming, shaping and structuring" (Jorgensen and Sorensen, 1999, 416p). Based on this view, innovation activities dispersed over multiple locations were integrated in the process of the development of HDTV as an emerging telecomunications technology.

The case of WiBro highlighted such emergent and dispersed processes, yet were coordinated to a degree. By applying the concept of an arena, I observed the dispersed innovation processes from the stage where they were only loosely linked through individual lines of interactions, mobilised in prior structures and boundaries

of interactions, such as spectrum-allocation regulation and related research organisations; national R&D programmes; and standard setting at the Telecommunications Technology Association (TTA), an ICT-standardisation association in Korea. Through an emergent process of coordination, the WiBro case showed how robustness for technological innovation was built up, to an extent, to the successful development of a complex infrastructural technology. The WiBro case, however, further exemplified that such robustness in a particular innovation path needs to break down and flexibly respond to changing relations and evolving technologies, such as, as it reached the stage of application and commercial uptake.

The main interest of this study has thus been in examining the configurational process where the choices through past activities and interactions, present positions, and strategies, as well as future outlooks co-shaped the technology. It is a process represented by changing roles and interactions in which the key problem is to solve the question of how to accommodate uncertainties of the future. This study has particularly focused on the opportunities and challenges of coordination over the lifecycle of an innovation of a large-scale infrastructural technology. Coordination in the case of WiBro was a major attempt by the government and other players to develop a novel technological infrastructure and service in South Korea. An overarching aim was to achieve technological leadership in the global telecommunications market while solving and tackling immediate problems arising in the domestic market of South Korea. Yet, although the coordination effort led to a degree of successful development of a novel infrastructural technology, it faced challenges as it came to the stage of commercialisation. This research has attempted to explicate the differing dynamics leading to the stages of technological development and commercial uptake.

In the course of this research, the research questions were modified a few times: in particular reflecting the changes in the definition of the gap that was assumed in this research. Initially, the research questions addressed the problem of diffusion, which sought to explain and to remedy the gap between expectations and actual uptake of technological innovation. However, gradually I came to see the gap as an inherent feature of this particular history of technological innovation of WiBro rather than a

problem that could be tackled with an immediate solution. The research questions were finally revised and addressed as follows:

RQ. 1. What are the dynamics that led to the design and development of an emerging technology of WiBro?

- How did alignments among the innovation players emerge and evolve towards the design and development of WiBro?

RQ. 2. How were the WiBro services deployed, and what caused the gap between the initial visions of WiBro and the commercial uptake?

- What choices did the innovation players make, how did they interact towards the commercialisation of WiBro, and how did the WiBro services evolve?

RQ. 3. How did WiBro services evolve, and how and to what extent could the gap be mediated?

- How did the dynamics of innovation differ through the stages of technological development and uptake, and how should the gap be addressed?

The first research question aimed to explicate the dynamics leading to the development of a complex infrastructural technology. It aimed to examine the aims, visions, purposes, and intentions of varying interests involved in the process of developing WiBro technology, as these constitute the choices that shape the coevolution of technology and society. In particular, coordination was the key focus of inquiry, especially linked to the process of design and development of large-scale, complex technologies and systems.

The in-depth case study of WiBro demonstrated an emergent process of forming alignments and coordination that arose through interactions among diverse interests. Multiple interests were initially prompted by particular individual needs and aims upon availability of a critical resource for innovation: the 2.3GHz spectrum

frequency band. Rather than drawing on the process of building alignments through a particular role, a powerful vision, or an authority (Ansari and Garud, 2009; Yoo et al., 2005), this study examined the process in which several arenas were formed as multiple interests reached out for what seemed to be available resources, tools, and actions for future innovation. Initial coordination took place in relation to spectrum allocation as the multiple stakeholders aimed to secure the licenses for the spectrum, albeit for differing purposes. This formed an innovation arena ('spectrum arena') constituted by interests and alignments that sought to bring about an innovative use of the spectrum resource. A generic vision of an emerging telecommunication technology and service was shaped through the negotiations held in this coordinated arena: the Portable Internet, later renamed WiBro.

Upon shaping the generic vision of the Portable Internet and MIC's subsequent regulatory decision on the reallocation of the spectrum frequency band, a national R&D programme was formed and coordinated as a national scale R&D aimed at developing a technological system, HPi, that realised the vision of the Portable Internet. Yet, such alignment was incomplete in that participating players sought and preferred differing, competing choices of technology for commercial deployment. These differing options were competing to set the standard for Portable Internet, as the spectrum policy had designated a single standard to be developed and deployed for commercial Portable Internet service in the domestic market. The differing choices and competing alignments converged around a single type of technological specification through standardisation.

The standards arena was established by MIC, as MIC coordinated a standard-setting group through TTA, deciding to bring Portable Internet service at the 2.3GHz frequency band as a single standard. The generic vision that had been shaped through negotiations at the spectrum arena was thus relayed to the standards arena where diverse arrays of players participated in the standard-setting process. The three innovation arenas were linked through the standardisation of the Portable Internet through which HPi technology was selected as the baseline technology for the single standard.

The emergent process of building alignments and shaping relations towards the innovation of WiBro is illustrated in Figure 5:
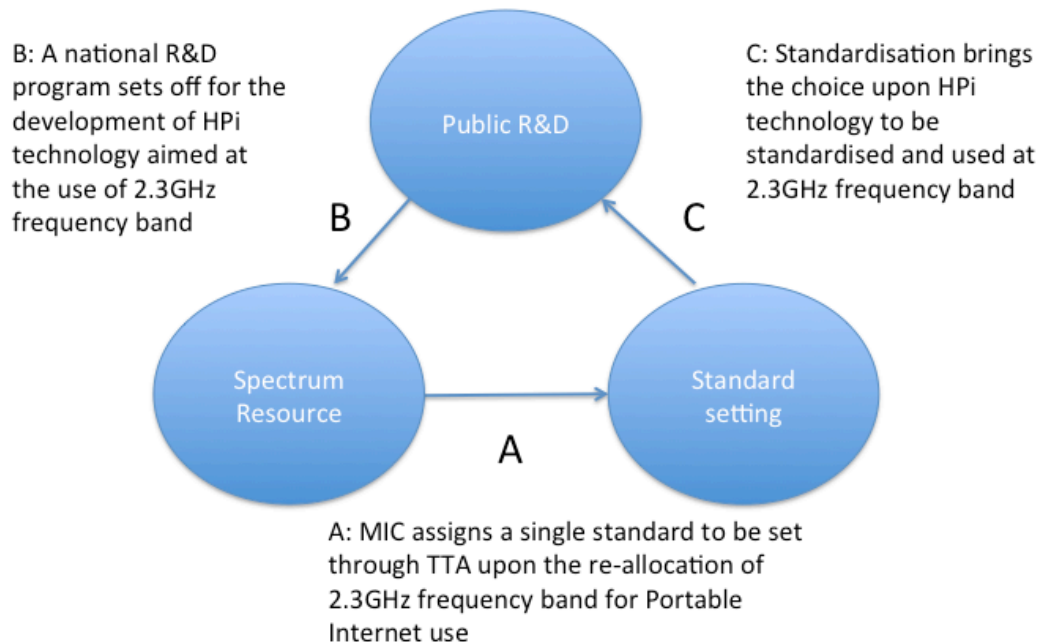

Figure 5. Interlinked structures for the development of WiBro.

A seemingly complete alignment was established between the emergent arenas of innovation. However, an in-depth case study further explicated this process as involving tensions and disputes that coexisted through the emerging alignments. In the spectrum arena, disputes around the boundary between fixed and mobile as the fixed-line carriers and the mobile operators were together involved in defining the feature of *wireless* for the emerging convergence service, Portable Internet. In the national R&D arena, differing intentions and differing commitments existed towards the development of HPi system, despite their formal collaboration in the R&D programme. In the standards arena, a large number of players in the telecommunications field participated in the shaping of the standard whereas diverging choices arose in candidate technologies in the pre-commercial market for Portable Internet. These tensions and disputes were moderated yet not resolved, as the alignments were effectively configured through the standard-setting process.

The process of building alignments also involved interactions of aligning visions among multiple interests in and beyond the initial boundaries of arenas. For example, as Samsung began to participate in the national R&D programme for HPi, it began contacting foreign players including the international standard-setting organisation, IEEE, thereby making an informal linkage between HPi and IEEE. This brought HPi to be more closely aligned with TTA's vision for globalisation of the national standard. HPi was finally chosen as a technological base for a Portable Internet standard, yielding a formal linkage between the HPi and TTA. TTA then approached IEEE and the two organisations reached harmonisation of their standards after going through a number of negotiations, thereby bringing a formal linkage between TTA and IEEE. Through the process of building alignments, often supported by coordination, the HPi was successfully developed based on the global standard, and became the world's first commercialised system.

The processes involving tensions, conflicts, and active engagements in forming strategic relations, however, brought recognition of an 'incompleteness' of alignment, backed by a formal configuration of a seamless alignment. The standardisation seemed to have brought about a degree of 'closure' to diverging choices by configuring alignments around a single national standard. However, the tensions and conflicts were not completely resolved but only mediated to reach a formal agreement through regulatory decision making. Also, shifts in alignments and relations could be observed, as the national standard was harmonised with an international standard. Furthermore, alignments further extended as the standardisation was extended to be linked to other international standards-setting fora, including WiMAX Forum and ITU.

This case study demonstrated how the shaping of a generic vision indeed brought multiple interests to be aligned to certain processes of innovation. In studies of sociotechnical innovation and change, scholars have often placed emphasis on the role of "guiding visions" or expectations that motivate multiple actors to be aligned towards a particular goal (Berkhout et al., 2004a; Borup et al., 2006; Rotmans and Kemp, 2001). The generic vision implies the vision is 'generative' (Borup et al.,

2006, 285p): the vision becomes the source for generating activities, providing legitimation and attracting diverse interests. Yet, the generic vision observed through this case of WiBro suggested a vision that could be appropriated by many whose immediate aims and goals differed to a degree. Thus, I observed the players to be actively involved in the process of shaping the vision through negotiation, and also appropriating the vision in relation to their particular histories, present needs, and future goals. In fact, through the emergent process of coordination, one could observe how multiple interests were actively searching, while at the same time being effectively aligned towards and through the shaping of the generic vision of Portable Internet/WiBro.

In the beginning, I intended to link the findings about unresolved problems and conflicts as well as shifting relations and alignments to the problem of what I had perceived as a problem of diffusion; a view supported by a perspective that technology is 'ready-made', and thereby perceiving users as passive recipients of a taken for granted technology (Sørensen, 1996). However, the ongoing process of shaping and appropriating the generic vision of an emerging technology seemed to suggest it would be misleading to interpret such findings as causes for what was regarded as a diffusion lag by the holders of a static vision of the technology being widely diffused. Rather, these findings linked to design and development of a complex infrastructural technology and standard led to a question about how   these visions, alignments, and technology were further shaped by the process of appropriation of the technology as a product that was finally marketed and used.

The second research question has guided such further search, especially focusing on the gap I and others initially recognised as a *diffusion gap*, yet which was further understood in relation to a gap between initial visions and expectations and actual outcome of technology uptake.

> RQ. 2. How were WiBro services deployed, and what caused the gap
>   between the initial visions of WiBro and the commercial uptake?

- What choices did the innovation players make, how did they interact towards the commercialisation of WiBro, and how did the WiBro services evolve?

This inquiry links the story of the technological development with that of the commercial uptake. By applying the concept of *appropriation* from the social-learning framework (Williams, 2000; Williams et al., 2005), I explicated the process of a generic vision, technology, and standard being appropriated by the intermediate players towards the commercial use of WiBro systems and services: in particular, through the process of coproducing commercial products and services based on the single standard of WiBro. This has led to identifying further dynamics influencing the shaping of WiBro service during commercial uptake and use.

I observed how the alignments to bring about commercial WiBro service had been configured around the single national standard set through TTA and extended as a global standard. By linking this process of setting standard and the attempts to adopt the standard, this case study highlights the divergent choices on appropriating the standard to particular services to be deployed in the commercial market. Such availability of diverging choices around the single standard was especially demonstrated as the players competed for licenses for WiBro service in the 2.3GHz frequency band. Each player proposed differing visions and strategies as well as differing applications and business models towards the deployment of the single standard for WiBro. Such reflected differing interpretations of a generic technology and standard depended on their own differing histories and background, current positionings, and future goals and strategies in the evolving telecommunications market. This comprehensive observation of the processes of appropriating the generic vision of WiBro towards the future deployment of WiBro service demonstrated how the availability of divergent choices was mobilised, as the players involved themselves in what could be viewed as a 'multi-level game'(Williams et al., 2005) where the players pursue their own covert goals while still being aligned to formally shared goals.

During the process of actual deployment of WiBro services, based on collaboration among the partnering players, however, that multilevel game was further observed to be leading to certain discrepancies in the process of coproducing commercial WiBro products and services. First, discrepancies were observed between the manufacturer of WiBro systems and the operators, as they came to together appropriate the WiBro standard into commercial products and services. Although they had been closely aligned towards the vision of globalising the domestic WiBro standard, there was a degree of differing urgency towards the commercial deployment of WiBro products and services in the domestic market. This was due to the differing goals and concerns by the manufacturers and the operators linked to adopting the global standard in the domestic market: the manufacturers aimed to achieve global leadership through the world's first deployment of their own product systems, whereas the operators preferred to secure wider interoperability before the actual deployment of the service.

Through the comprehensive case study, I observed how unforeseen choices were made, especially as the players responded with differing capacities, goals and strategies, to the large-scale investments to be made. Hanaro Telecom returned the spectrum license it had acquired before actual deployment efforts took place. SKT, the mobile operator, did not actively pursue the commercial deployment of WiBro service as its own existing and fast-evolving network of HSDPA (High-speed Downlink Packet Access) was increasingly viewed as competing with WiBro in future services in the market upon full deployment. KT had therefore become the sole operator of WiBro actively engaged in the process of commercialisation; their efforts did not expand through competition but were rather faced by oppositions and obstacles towards the deployment of advanced WiBro services. SKT soundly opposed KT's plan to bring about VoIP service as an outstanding application for WiBro, which resulted in a lack of active engagement of the existing mobile-phone industry in collaborating with KT. Such lack of competition for deployment of the commercial WiBro network and service in the market and discrepancies in the process of coproduction of commercial WiBro products and services further resulted

in unmitigated problems of limited network coverage and lack of outstanding applications even 3 years after the initial launch of commercial WiBro service.

In contrast, the global market for Mobile WiMAX, to which WiBro was a service profile, seemed to expand rather rapidly, whereas the Korean manufacturers and operators were actively expanding their business by exporting and deploying their products and services in foreign markets. Furthermore, such increasing adoption of Mobile WiMAX in the global market was further accompanied and strengthened by the inclusion of the Mobile WiMAX standard in the mobile communications standard of IMT-2000 designated by the ITU. The advancement of the market for Mobile WiMAX (including WiBro profile-based systems) also brought about disputes in Korea regarding the role of a domestic policy to promote WiBro service: that is, whether to promote the domestic market for WiBro or concentrate on foreign markets by recognising the different market needs for WiBro/Mobile WiMAX between the domestic market and the markets abroad. Indeed, such diverging outcomes of the commercialisation of WiBro and Mobile WiMAX between the domestic and global markets represented a degree of differing and diverging modes of uptake of the generic standard between the national boundaries of the marketplace on which the standard was appropriated through implementation and use.

I observed additional divergence in certain areas of WiBro applications and products in the Korean domestic market. Although the producing and marketing of advanced types of WiBro services using PDAs and mobile phones were constantly faced with challenges of commercial uptake, USB modems and mobile routers to access the Internet through WiBro seemed to stabilise as a representative WiBro service in the telecommunications market. As there were a small number of users of such service in the market, it was considered a niche-market service. I also identified other niche-market services as the operators, especially KT, struggled to bring about WiBro services to market at an appropriate level of adoption compared to their other current investments. These included WiBro applications deployed in a taxi company to hire taxi services, as well as building of an advanced digital communications infrastructure in the world's leading shipbuilding company based in Korea. Such deployment of WiBro services demonstrated how the modes of uptake of the generic

technical capabilities of WiBro could differ, depending on varying factors such as the industry fields that were adopting the service, the service types, market sizes, commitments by the members supplying and adopting the service, and many others. In such niche-market areas, I observed relatively strong commitments of the interacting players (e.g., between KT and Moda), whereas their interactions led to an innovation that had not been foreseen (i.e., mobile routers). In particular, in the case of HHI's deployment of WiBro to build the digital shipyard, creative innovations took place during use of the WiBro service, that produced further innovations in developing WiBro-enabled products and services based on the close interactions among committed members of the company.

The close examination and a comprehensive analysis of the interactions among the innovation players—mainly at the intermediate level of appropriation of commercial products and services—thus highlighted the complexities and contingencies in the process of appropriating the generic technology and standard to specific service deployment and use. Varying, and often unforeseen sociotechnical factors influenced the choices that shaped WiBro products and services. This, in the case of WiBro, resulted in the market uptake of WiBro products and services that largely deviated from the initial visions and expectations. Such complex processes involving varying contingencies during the process of appropriating the generic technological offerings highlighted an aspect of the learning process: Although at a much smaller scale and in limited application areas than had originally been perceived, the experiences and the interactions among the committed developers, users, and intermediaries of WiBro niche-market services demonstrated the social-learning process (Williams et al., 2005). The process entailed a cyclical-learning process between the committed players whose perceptions, strategies, and actual adoption of particular technologies, infrastructures, or services further led to niche innovations within the limited boundaries of their application areas.

However, the boundary of such cyclical-learning processes among the committed players did not expand. Indeed, this case demonstrated the depth of a cyclical learning process that resulted in further innovation through adoption and use. In addition to the comprehensive learning process explicated through the study, I also

observed the choices that delimited the boundary of such a learning process: the boundary of the application areas of WiBro. I discuss this topic in answering the third research question, which inquires about the additional choices that shaped the evolution of WiBro services.

> RQ. 3. How did WiBro services evolve, and how and to what extent could the gap be mediated?

> - How did the dynamics of innovation differ through the stages of technological development and uptake, and how should the gap be addressed?

Since the initial conceptualisation of WiBro as an emerging 'home-grown' mobile and fixed-convergence technology and service in the early 2000s, the technology and standard evolved rather rapidly and, to an extent, rather radically. The WiBro service profile of Mobile WiMAX evolved to 3G mobile communications along the inclusion of Mobile WiMAX in the IMT2000 family of mobile-communications standards by the ITU in 2007. It further evolved to 4G (IMT-Advanced) standard as it was officially acknowledged to be included in the IMT-Advanced family of standards along with LTE in 2012. Mobile services also evolved, with a rapid increase in the use of wireless/mobile-data communications, driven by the innovation in mobile phones, represented by the introduction of the iPhone and smartphones. Accompanying these changes were rising expectations and policy-oriented efforts towards the eventual rise in the market uptake of WiBro services in Korea. However, despite such anticipations and expectations along the rapid evolution of mobile standards and services, WiBro service in Korea did not further expand in its applications areas and the scale of adoption from niche-market services.

Such a contemporary yet longitudinal case leaves the research to be placed still in a fluctuating space and time to observe ongoing interactions that are shaping the technology and the services to coevolve in a certain direction. The problem of uncertainty continues whereas this study explicated the complex interactions that led to diverging choices and outcomes, resulting in a degree of deviation in the current mode of uptake of WiBro away from initial visions and expectations. By answering

the third research question addressing to what extent and how the gap was mediated, I do not attempt to solve the problem of uncertainty. Instead, I bring a discussion regarding what has further shaped the boundaries of such complex interactions in the process of disseminating WiBro technology and services over time.

I observed that operators made radical choices that shifted away from and delimited the interactions from pursuing the initial goal of realising advanced fixed-mobile convergence portable multimedia service. To begin, there was a radical shift in the choices of key intermediaries, the operators of WiBro. KT merged with its mobile subsidiary and second-largest mobile operator in Korea, KTF, in 2009. This resulted in KT's radical shift in the choice for applying VoIP as a key strategic service for WiBro, as VoIP would be a threat rather than an opportunity for a mobile operator. Such a radical shift in choice resulted in the reshaping of KT's vision of WiBro away from next-generation fixed-mobile convergence service towards a data-centric mobile network for providing Internet-access service. Furthermore, as the mobile technologies and services evolved towards 4G telecommunications, both operators of WiBro, SKT and KT, chose to evolve their networks through the Long Term Evolution (LTE) standard, which was then competing with WiMAX as two evolving standards towards next-generation mobile communications.

Such radical shifts in the choices of key operators of WiBro resulted in a controversy around the South Korean policy to promote WiBro service in the domestic market. The controversy resulted in part from discerning the gap between the initial visions and expectations of WiBro and actual uptake. At the same time, it resulted from the need to make further choices in the future shaping of WiBro service in the domestic market, through the renewal of WiBro licenses. Therefore the controversy represented a learning process where differing choices from differing backgrounds and knowledge were reflected. Following the controversy, especially in relation to the renewal of the spectrum license for WiBro, KCC made the final choice on renewal of licenses to KT and SKT. That decision was regarded as an acknowledgement of the changes the operators had made on the positioning of WiBro service in the current and evolving market of mobile communications. The decision therefore involved the reshaping of the generic vision of WiBro, which had

long been guiding WiBro policy: WiBro, which had initially been conceived as a fixed-mobile convergence service, was positioned as a data centric mobile Internet service to complement existing mobile services and telecommunications infrastructures.

Therefore, the gap that had initially been identified as a diffusion problem, and then as an inherent aspect of the innovation process involving complex interactions, finally came to be viewed as a space also filled with interplays among players involved in the reshaping of the generic vision of the technology. Then, the question of how to mediate the gap emerged in the question of how to accommodate changing contingencies over the lifecycle of a technological innovation. Indeed, South Korea is still facing uncertainty with regard to the future evolution of WiBro towards TD-LTE. Whilst controversy had arisen about the need to shift the use of spectrum licenses in the 2.3GHz frequency band from WiBro to TD-LTE, recent WiBro policy has allowed an additional spectrum license in the 2.5GHz frequency band for either WiBro or TD-LTE service use, whichever is selected by the new licensee. The interactions among players with differing backgrounds, differing capacities, and differing knowledge, as well as differing strategies for the future have thus resulted in the reshaping of WiBro policy to accommodate changes in domestic needs as well as increasing choices in TD-LTE by global WiMAX operators.

Therefore, this comprehensive longitudinal case study of an emerging large-scale infrastructural technology and service has demonstrated how the dispersed processes of innovation over multiple arenas were coordinated to co-shape the generic vision of an emerging technology. Coordination in the early stages of technology design and development involved mediating differing interests towards the shaping of a generic vision. However, as multiple interests came to appropriate the generic vision into developing and deploying specific commercial products and services, coordination challenges arose in how to mediate the gap between the initial visions and actual uptake; between diverging choices upon appropriation; as well as through changing contingencies over time. Coordination efforts were then aligned with the process of reshaping the generic vision of the technology. Such a demonstration of a complex and contingent processes involving the innovation and the evolution of a

large-scale infrastructural technology thus suggests a mode of governance that accommodates both the complexities and the changing contingencies inherent in the process of design, development, and commercial uptake of innovation.

7.3 Towards the Distributed Governance of Technological Innovation

This longitudinal study of WiBro thus suggests a particular mode of governance of technological innovation and change: a *distributed governance of innovation.*[82] Based on this research on the case of WiBro, *distributed governance* has been conceptualised as having decentralised coordination efforts by the government and others in initiating, appropriating, and further shaping the generic vision of an emerging technology. Thus, what is distributed depends on what is at stake: it may be differing aims and purposes that bring players to act; it may be differing knowledge that constitutes complex technological systems; it may be differing arenas of innovation that emerge towards innovation; and it may be the diverse setting and relations that change over time. The distributed governance of innovation is particularly relevant to large-scale and complex technologies where dispersed innovation takes place. Dispersed innovation denotes the dispersed processes of innovation that take place based on current structures of innovation with particular histories, backgrounds, and capacities, mobilised by individuals who are actively engaging themselves to available resources, activities, and tools to shape certain technologies.

The distributed governance of innovation model, based on this study, suggests a flexible approach towards shaping, developing, and appropriating the generic vision and technology that need to be constituted through a multiplicity of interactions and engagements over a lengthy scale of time, for example, large-scale infrastructural

---

[82] The term distributed governance was first mentioned by Williams in relation to this research, suggesting the term be linked to explain conflicting interests that were yet governed (Meeting note on 28 June 2010). Williams later explained the distributed-governance models as involving two elements: *governance*—moving towards an interactive process of policy intervention where the state also becomes part of the governance process; and *distributed*—denoting an intervention brought by changing rules of interactions, leading to a widely dispersed mutual shaping process involving diverse players (in Suh, J. H., and R. Williams, 2013, Standardisation: a configurable space for the distributed governance of innovation, Research provocation for IFRIS/DIM IS2-IT International Workshop; Standardization as space(s) for innovation, Champs-sur-Marne, France.)

technologies.[83] Based on this research, the term 'flexibility' may denote having a decentralised structure for coordinating innovation: coordination can be brought by availing dispersed spaces for interactions through which the generic vision is shaped towards a collaborative and collective large-scale innovation, as was demonstrated in the shaping of innovation arenas in this research. Flexibility, however, may also be related to requiring a degree of learning process during the shaping of the technological innovation, which may result in accommodating differences into what is being shaped. Further, flexibility may denote an institutional ability to accommodate changing visions, choices, and strategies of involved innovation players.

Therefore, central to flexibility is the social-learning process (Williams et al., 2005): the process that involves negotiation between conflicting interests, often with different capabilities and commitments by players with differing backgrounds from which they become involved. Yet, this research has brought further emphasis to how learning could be accommodated: for example as shifting choices by the innovation players, as changes in the generic vision of technological innovation, and as bringing changes in policy. By accommodating not only the complexities—observed through the interactions of diverging and a multiplicity of choices, but also the changing contingencies that occurred through the choices of evolving technologies, services, and industry—innovation may be unhindered by the compressed story of an innovation: the story that brings the gap between initial visions and actual outcomes in need of being mediated.

---

[83] I recently encountered a paper that explicitly discussed the concept of flexibility in relation to long-term changes in information infrastructure (in this case, a research infrastructure) face (Ribes, David and Polk, Jessica Beth. 2014. *Flexibility Relative to What? Change to Research Infrastructure* Journal of the Association for Information Systems 15 (5)). The author approached the concept of flexibility especially in relation to research infrastructure that needs to be adaptable and resilient to what it must support; such as scientific research. In the ongoing processes and changes that occur in the long time scale of sustained research, 'flexibility' is considered not as a thing but a capacity that can be understood as being relative to forms of change.

Chapter 8. Conclusion

Central to this thesis has been the multiplicity of choices and the issues related to how to coordinate or build alignments through changing processes of a large-scale innovation over time. The single longitudinal case study of WiBro has provided an opportunity to examine the complex interactions among the varying industry, government and other players as constituting the process of building and configuring alignments towards shaping and achieving the particular vision of WiBro. The vision had been shaped as a generic vision upon which multiple interests projected their own aims and purposes. This longitudinal study has provided insights into how the generic vision was further shaped and reshaped as the innovation players sought to appropriate this generic vision towards the commercial deployment of particular WiBro systems and services in the current telecommunications market.

This research was initially motivated as a research on the process of diffusion of innovation. Adopting a processual approach to investigating the shaping of WiBro brought a shift away from seeking for the factors that caused the low market uptake of WiBro – widely diagnosed as the problem of diffusion. Indeed, during recent years WiBro has increasingly been regarded not only as an innovation which failed to achieve initial expectations and visions. WiMAX, to which WiBro belongs as a service profile, has also been widely viewed as having failed to secure its position in the next-generation (4th generation or 4G) communications market around the world, in competition with LTE. Thus, during the recent period in which this research has been carried out, scholars have investigated the causes for such an outcome, aiming mostly to bring about lessons from the past choices and the current outcomes. These studies have suggested varying reasons for the lack of wide adoption of WiBro in the domestic market of South Korea and beyond, such as: the barriers faced by innovation of WiBro due to the market being defined by the incumbent players of existing mobile communications (Kang et al., 2011); the dismantling of actor networks around WiBro as a fourth generation (4G) communications standard (Shin et al., 2011); the lack of service capabilities and service-related activities by the

relevant players (Kim et al., 2014); and institutional rigidity that has delayed institutional rearrangement necessary to bring about new large-scale ICT systems (Choung and Hwang, 2013).

To some extent, learning from the past towards making *better* choices for the future may be a necessary procedure in the aftermath of a collectively driven innovation efforts into which a large number of players have invested significant resource and time. However, such learning is often guided by a 'compressed (hi)story'[84] of WiBro: a history or a story of WiBro told against a set of values and visions that were created in the initial stages of technology design and development. By telling a story based on a widely accepted criteria of past choices or results (e.g. wide market diffusion, socio-technical transition, etc.), however, one may overlook the necessity for reconstructing the criteria – often including the vision and the values towards which alignments are formed. This research has demonstrated the need for a broader approach towards the learning that incorporates the past, present and the future: Learning, therefore, should be extended to incorporate an ongoing process of changing perceptions and actions that are brought to be negotiated and further shaped into producing an alignment or a coordination towards a particular innovation path.

Contribution to knowledge

This study has contributed to enhancing our understanding about the complex processes of innovation by broadening the view of innovation processes: from a process confined by the initial statement of goals and visions towards a process of co-configuring the changing visions, technologies and policy. The longitudinal study of an evolving technology has traced the emergence of multiple arenas of innovation where complex and shifting relations were examined as they together shaped the

---

[84] 'Compressed (hi)story' in this sense is closely linked to and may be juxtaposed with the 'compressed foresight' (Williams 2006): The term 'compressed foresight' was used to refer to the attempts to look into the future in greater detail, resulting in making the future seem imminent, as if it were sure to come, thus making the future "compressed into the present" (Williams 2006, 328p). 'Compressed history' may also be in some cases corollary to the 'compressed foresight': the story or a history of a particular innovation is reviewed and told against the scenarios that were formed through the compressed foresight.

technology over time. This delineation of multispatial and multilevel dynamics has resulted in laying out a 'biography' of WiBro, thereby contributing to those attempts to gain more indepth understanding of the complex processes of socio-technical change through the study of the biography of technologies (Hyysalo, 2010).

This study also contributes to knowledge by extending the scope of social learning beyond the development and use of the technology. The complexity that has been observed through the case of WiBro encompasses not only the problems and challenges ensuing from the diversity of interests and choices of multiple players, but also the changing contingencies over time. The shifting relations and commitments of the players, as well as the changing visions of WiBro across differing arenas of innovation and over time have provided a further comprehensive understanding of social learning taking place over multiple cycles of technological innovation.

The case of WiBro thus suggests the prospects of a technology cannot be understood simply in terms of the features of the technology being shaped: rather, the sustainability lies in the ongoing process of co-shaping the visions, technologies, policy and overall activities of the society in making choices upon future.

Reflections and future research

In the course of this research, my own research choices have been shaped by various factors, e.g. accessibility to research sites and interviewees, and interview contents, let alone the problems defined and the research questions. They in turn, have shaped the depth and the boundaries of research. I have made observations particularly on the interactions among the developers and intermediate users who were the co-producers of the commercial products and services. The interactions observed were mostly based on the resulting choices and actions made at the organisational level – e.g. the corporate decisions, and inter-firm relations and interactions. By investigating these interactions, I have been able to demonstrate how a distributed governance gained a momentum to shape and reshape particular pathways of innovation. The empirical focus on a large number of innovation players across

different arenas over time meant that the position of each organisation was characterized by a limited numbers of interviews with organization members and gave little scope to study differences within organisations. In consequence, the process of decision-making and attendant conflicts and negotiations within an organisation has in effect been black-boxed – and not studied systematically. Individual firms and organizations by default have thus been framed as single unitary actors whose inner concerns and conflicts were not taken into account of, despite their influence upon shaping the corporate or organisational decisions. Further research might usefully bridge intra- and inter-organisation interactions. By being able to link decision-making processes within and between organisations, the future research may benefit from more comprehensive and detailed understanding of multi-level interactions leading to particular choices and the potentially complex games played within as well as between firms in distributed governance.

The focus upon the intermediate level interactions involving the suppliers, government and the operators of the WiBro service leaves another sphere of interactions unexplored – viz the interactions between the suppliers and end-users. In fact, many studies on the market adoption of WiBro have resorted to survey based research on the potential or current customers of the WiBro service. The choices of end-users are indeed an important facet of the technology being shaped, and they do play a significant role in the shaping of the innovation process. However it has not proved possible to give adequate attention in this research to the role of the end-users and their interactions with the supply side players during the process of design, development and use of WiBro. The domain of end-user interactions with the suppliers of the technology and service is indeed a space that must not be overlooked, especially concerning large-scale infrastructural innovations (e.g. ICTs, energy sector innovation). These innovations often entail a significant portion of negotiations at the level of setting the rules of the game – i.e. setting standards, making regulatory decisions, etc. – which mainly involve suppliers and intermediate players that can only draw upon imperfect images and representations of potential end-users that may be filtered and shaped thought their world view and interest. This can be potentially very dangerous in bringing about innovations particularly where

these have pervasive impact in society and become entrenched. Therefore, it is also important that future research should address these problems and study the juncture of these often separate fields of study.

Implications for policy

In Korea, the uncertainties confronting a large number of innovation activities – often supported and coordinated through policy – have also been described and analysed in relation to the changing mode of innovation activities by industry as well as the nation's innovation policy: e.g. regarding the challenges of going from catching-up to post catching-up modes of innovation (Choung et al., 2014; Song and Lee, 2007; Song et al., 2007). The term "post catching-up"[85] mainly indicates the technology leadership achieved by the Korean national firms in the recent decade that came to pursue innovation by constructing their own foresight processes (Song and Lee, 2007; Song et al., 2007). Framing the uncertainties in relation to the technology leadership achieved emphasises the rising needs for the players to develop capabilities for dealing with unforeseen impacts and outcomes. In addition, it implies the need for change in the roles of the institutions – mainly the government and the public research institutes – that have traditionally offered leadership in coordinating and supporting industry towards innovation (Choung et al., 2014; Kwak et al., 2012).

Whilst the change seems endemic to the current mode of governance of innovation in Korea, it is also evident in other economies. Though it is a particular feature of innovation of new ICT infrastructures where the scale and complexity of developments goes beyond the capacity of individual firms, some aspects are evident

---

[85] Although I mention the concept of 'post catching-up' here, I bring the concept only to refer to one aspect of policy framing of uncertainties of innovation. An informal conversation about the concept with my colleague Eunsun Kim has prompted me to have this stance. I have however mentioned the concept in relation to this study of WiBro as some scholars have considered WiBro as an exemplar case of what they frame as "post catching-up" innovation policy (Song, W., D.-o. Park, and Y.-j. Kang, 2007, Managing Techno-economic Uncertainties in the Post catch-up stage, Science and Technology Policy Institute); Choung, J.-Y., H.-R. Hwang, and W. Song, 2014, Transitions of Innovation Activities in Latecomer countries: An Exploratory Case Study of South Korea: World Development, v. 54, p. 156-167)

in other technological developments. The *distributed governance of innovation* model proposed in this research offers a way to bring about such change: to achieve and involve reflexivity in the course of coordinating and directing certain activities towards innovation, through the interactions with the diverse players whose interests are often dispersed over multiple choices and cycles of innovation process. Coordination, upon which the role of the government has long been emphasised, may then be considered not as a thing to be pursued towards achieving a robust alignment, but as a process that requires constant reshaping through cyclical processes of negotiation among the diverse interests. We hope that this study can contribute to more effective innovation strategy and governance.

Bibliography

Ahn, J. H., C. R. Yang, and Y. I. Kim, 2003, High-speed Portable Internet (HPi) Technology: Telecom, v. 19.

Ahn, J.-M., 2007, WiBro Future Outlook: KTOA, v. 42.

Ahn, K. S., 2004, [Special Edition] Current Trends in Portable Internet or Related Solution Providers. Digital Times.

Ahn, S. G., 2009, An Analysis of Performance and Success Factors of National R&D Project - Focused on the Next Generation Growth Engine Program , in KISTEP, ed.

Akrich, M., 1992, The De-Scription of Technical Objects, *in* W. E. Bijker, and J. Law, eds., Shaping technology/building society : studies in sociotechnical change: Cambridge, MA: MIT Press, p. 205-240.

Akrich, M., 1995, User Representations: Practices, Methods and Sociology, in A. Rip, T. J. Misa, and J. Schot, eds., Managing Technology in Society: The Approach of Constructive Technology Assessment. London: Pinter, p. 167-184.

Ames, P., and J. Gabor, 2000, The Evolution of Third-Generation Cellular Standards: Intel Technology Journal, v. Q2.

Ansari, S., and R. Garud, 2009, Inter-generational Transitions in Socio-technical Systems: The Case of Mobile Communications: Research Policy, v. 38, p. 382-392.

Arthur, W. B., 1989, Competing Technologies, Increasing Returns, and Lock-in by Historical Events: The Economic Journal, v. 99, p. 116-131.

Ayvazian, B., 2013, White Paper: WiMAX Advanced to Harmonize with TD-LTE in the 2.3, 2.5 & 3.5GHz Bands Opportunities & Challenges for WiMAX 2 Heavy Reading.

Back, Y. D., 2001, Thrunet to enter Wireless data, ADSL business in the first half year (19 January 2001), Digital Times.

Back, Y. D., 2004, Conflict over Portable Internet Standard to be put on vote, Digital Times.

Baek, Y. D., 2004a, Competition for Portable Internet Market Preoccupancy is 'hot', Digital Contents, Seoul, Korea.

Baek, Y. D., 2004b, Portable Internet/ Key issues , Digital Times, Seoul, South Korea.

Bass, F. M., 1969, A New Product Growth for Model Consumer Durables: Management Science, v. 15, p. 215-227.

Belz, F. M., 2004, A transition towards sustainability in the Swiss agri-food chain (1970-2000): using and improving the multi-level perspective, *in* B. Elzen, F. W. Geels, and K. Green, eds., System Innovation and the Transition to Sustainability: Theory, Evidence and Policy: Cheltenham, Edward Elgar Publishing.

Berkhout, F., A. Smith, and A. Stirling, 2004, Socio-technological regimes and transition contexts, *in* B. Elzen, F. W. Geels, and K. Green, eds., System Innovation and the Transition to Sustainability: Cheltenham UK and Northampton USA, Edward Elgar, p. 48-75.

Bijker, W. E., 1992, The Social Construction of Fluorescent Lighting, Or How an Artifact Was Invented in Its Diffusion Stage, *in* W. E. Bijker, and J. Law, eds., Shaping technology/building society : studies in sociotechnical change: Cambridge, Mass. ; London, MIT Press, p. vii, 341 p.

Blaikie, N. W. H., 2000, Designing social research : the logic of anticipation: Malden, MA, Polity Press, xiv, 338 p. p.

Bohlin, A., H. Gruber, and P. Koutroumpis, 2010, Diffusion of new technology generations in mobile communications: Information Economics and Policy, v. 22, p. 51-60.

Borup, M., N. Brown, K. Konrad, and H. Van Lente, 2006, The Sociology of Expectations in Science and Technology: Technology Analysis & Strategic Management, v. 18, p. 285-298.

Brosveet, J., and K. H. Sørensen, 2000, Fishing for Fun and Profit? National Domestication of Multimedia: The Case of Norway: Information Society, v. 16.

Byeon, D.-S., 2004, Portable Business Model and Service Provision Plan The Journal of Korea Information and Communications Society, v. 21.

Chang, Y. E., 2009, Hyundai Heavy Industry builds WiBro 'Digital Shipyard' , Yonhap News.

Chen, H.-H., and M. Guizani, 2006, Next Generation Wireless Systems and Networks, John Wiley & Sons, Ltd.

Cheong, Y. S., 2009, IT Convergence in Shipyard, IT Convergence International Conference 2009

Choi, H. J., 2003, MBWA International Standardisation Trends, ICT Standard Weekly, TTA.

Choi, J. S., 15 January 2004, The current trend in Portable Internet related Solution Vendors , Digital Times.

Choi, K. S., 2003, Competitions in high-speed wireless LAN system development, Digital Times, Seoul, South Korea.

Choi, Y., 2004a, A Reform of a Licensing System with a Focus on 2.3GH Portable Internet Service: Telecommunications Review, v. 14.

Choi, Y., 2004b, A Reform of a Licensing System with a Focus on 2.3GHz Portable Internet Service: Telecommunications Review, v. 14.

Choung, J.-Y., and H.-R. Hwang, 2013, The institutional rigidities in the transition phase from catch-up to forging ahead: The case of ICT systems innovation in Korea, 35th DRUID Celebration Conference 2013, Barcelona, Spain.

Choung, J.-Y., H.-R. Hwang, and W. Song, 2014, Transitions of Innovation Activities in Latecomer countries: An Exploratory Case Study of South Korea: World Development, v. 54, p. 156-167.

Chung, C.-H., and T.-J. Lee, 2002, Introduction to a standard technology for the use of 2.3GHz frequency band spectrum : TTA Journal, v. 84.

Chung, H. S., 2003, Recent Market Trend of Portable Internet and Implication , in K. EIC, ed.

Chung, J.-Y., 2003, How far would the competition on Portable Internet technology standard be?, ETnews.

Chung, J., 11 December 2003, How far will the competition of Portable Internet standards go , Electronic News, South Korea.

Chung, Y. H., 2012, WiBro, like Japanese Electronics Industry? Deepening sense of crisis, ZDNet Korea.

Chung, Y., 2008, WiBro - Will it work as promised? Newsletter, Korean Insight.

Correlje, A., and G. Verbong, 2004, The Transition to Gas in the Netherlands, *in* G. Elzen, and F. W. Geels, eds., System Innovation and the Transition to Sustainability, Edward Elgar.

Crotty, M., 1998, The foundations of social research: Meaning and perspective in the research process: London and Thousand Oaks, California, Sage Publications.

David, P. A., and W. E. Steinmueller, 1994, Economics of compatibility standards and competition in telecommunication networks: Information Economics and Policy, v. 6, p. 217-241.

Denzin, N. K., and Y. S. Lincoln, 2003, Strategies of Qualitative Inquiry: London, Sage Publications.

Deuten, J. J., A. Rip, and J. Jelsma, 1997, Societal embedding and product creation management: Technology Analysis & Strategic Management, v. 9, p. 131-148.

Dey, I., 1993, Qualitative Data Analysis: A user-friendly guide for social scientists: London and New York, Routledge.

Donmoyer, R., 2000, Generalizability and the single-case study, in R. Gomm, M. Hammersley, and P. Foster, eds., Case study method : key issues, key texts: London, Sage, p. ix, 276 p.

Fleck, J., 1988, Innofusion or diffusation? The nature of technological development in robotics, Edinburgh PICT Working Paper, Edinburgh University.

Fleck, J., 1999, Learning by trying: the implementation of configurational technology, *in* D. A. MacKenzie, and J. Wajcman, eds., The Social shaping of technology: Buckingham, Open University Press, p. xvii, 462 p.

Fomin, V. V., 1999, The Dynamics of Standard Setting: Equilibrium and Transformation in Social Networks: IEEE Conference on Standardisation and Innovation in Information Technology, p. 85-89.

Funk, J. L., and D. T. Methe, 2001, Market- and committee-based mechanisms in the creation and diffusion of global industry standards: the case of mobile communication: Research Policy, v. 30, p. 589-610.

Galbraith, M., 2005, Thrunet takeover to stabilize Korean broadband market, Telecom Asia.

Geels, F., 2002, Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study: Research Policy, v. 31, p. 1257-1274.

Geels, F., 2005, The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriages to Automobiles(1860-1930): Technological Analysis and Strategic Management, v. 17, p. 445-476.

Geels, F. F. W., and J. Schot, 2007, Typology of sociotechnical transition pathways: Research Policy, v. 36, p. 399-417.

Geels, F. W., 2002a, Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study: Research Policy, v. 31, p. 1257-1274.

Geels, F. W., 2002b, Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study: Research Policy, v. 31, p. 1257-1274.

Geels, F. W., 2010, Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective: Research Policy, v. 39, p. 495-510.

Gomm, R., M. Hammersley, and P. Foster, 2000, Case study method : key issues, key texts: London, Sage, ix, 276 p. p.

Graham, I., G. Spinardi, R. Williams, and J. Webster, 1995, The Dynamics of EDI Standards Development: Technological Analysis and Strategic Management, v. 7.

Haddon, L., 2005, The Innovatory Use of ICTs, *in* L. Haddon, E. Mante, B. Sapio, K.-H. Kommonen, L. Fortunati, and A. Kant, eds., Everyday innovators : researching the role of users in shaping ICT's: Dordrecht, Springer, p. vi, 238 p.

Hall, B. H., 2005, Innovation and Diffusion, *in* J. Fagerberg, D. C. Mowery, and R. Nelson, eds., The Oxford Handbook of Innovation: Oxford, Oxford University Press, p. 459-484.

Hanseth, O., 1996, Developing Information Infrastructure: The Tension between Standardization and Flexibility: Science, Technology & Human Values, v. 21, p. 407-426.

Holstein, J. A., and J. F. Gubrium, 2004, Active interviewing, in D. Silverman, ed., Qualitative Research: Theory, Method and Practice: London, Sage, p. 140-161.

Hong, D. H., 2007, WiBro Standardisation and Service , TTA Journal.

Hong, D. H., C. G. Kang, and Y. S. Cho, 2004a, Current Progress of Portable Internet Standardisation Information and Communication , v. 21.

Hong, D. H., C. G. Kang, and Y. S. Cho, 2004b, Domestic standardisation of 2.3GHz Portable Internet Technology TTA Journal, v. 20.

Hong, K. B., and W. S. Kim, 2005, Samsung, first time export of WiBro system , Electronic News, Seoul, South Korea.

Howells, J., 2006, Intermediation and the role of intermediaries in innovation: Research Policy, v. 35, p. 715-728.

Hwang, H.-T., 2004, KT WiBro Service Provision Plan.

Hwang, J. H., 2008, Building the WiBro Ecosystem , Electronic News, Seoul, South Korea.

Hyysalo, S., 2006, Representations of Use and Practice-Bound Imaginaries in Automating the Safety of the Elderly: Social Studies of Science, v. 36, p. 599-626.

Hyysalo, S., 2010, Health Technology Development and Use: From Practice-Bound Imagination to Evolving Impacts: Routledge Studies in Technology, Work and Organizations: London, Routledge.

ITU, 2007, ITU defines the future of mobile communications.

ITU, 2009, IMT-Advanced (4G) Mobile wireless broadband on the anvil.

ITU, 2012, IMT-Advanced standards announced for next-generation mobile technology.

Jang, B. J., S. H. Lee, and J. Y. Han, 2005, Telecommunications Market Structure Change due to Fixed and Mobile Convergence, in KISDI, ed.

Jang, S. K., 2013, Would WiBro Resurrect through 4G Mobile Communications, Korea Economy Magazine.

Jang, S. K., 2006, Industry-Government-Institute 'Three in one' collaboration has been illuminating, Hankyung Megazine, 4 September.

Ji, K. Y., C. G. Kang, Y. S. Cho, D. H. Hong, S. H. Yu, M. G. Kim, S. C. Kim, D. K. Kim, and J. H. Kang, 2004, Introduction to WiBro : Seoul, Electronic Newspaper.

Johnson, B., 1992, Institutional learning, *in* B.-Ê. Lundvall, ed., National systems of innovation : towards a theory of innovation and interactive learning: London, Pinter.

Joo, J.-O., 2007, Meaning of the adoption of WiBro as an international standard and our future roles : TTA Journal, v. 114, p. 13-21.

Joo, P.-Y., and J.-J. Son, 2006, The Current Standardisation and Outlook on IEEE 802.16/ WiBro/Mobile-WiMAX : TTA Journal, v. 103, p. 57-60.

Jørgensen, U., 2012, Mapping and navigating transitions - The multi-level perspective compared with arenas of development: Research Policy, v. 41, p. 996-1010.

Jørgensen, U., and O. Sørensen, 1999, Arenas of Development: A Space Populated by Actor-worlds, Artefacts, and Surprises: Technological Analysis and Strategic Management, v. 11, p. 409-429.

Jørgensen, U., and O. Sørensen, 2002, Arenas of Development: A Space Populated by Actor-worlds, Artefacts, and Surprises, in K. H. Sørensen, and R. Williams, eds., Shaping Technology, Guiding Policy: Concepts, Spaces & Tools: Cheltenham, UK, Edward Elgar.

Kang, I. S., H. M. Kim, and J. H. Chae, 2009, Issues in Intellectual Property Rights in the process of the development and standardisation of broadcasting and communications technologies in the convergence era : Broadcasting and Telecommunication Policy, v. 21.

Kang, J.-S., H.-Y. Lee, and J. Tsai, 2011, An analysis of interdependencies in mobile communications technology: The case of WiMAX and the development of a market assessment model: Technology in Society, v. 33, p. 284-293.

Kano, S., 2000, Technical innovations, standardization and regional comparison—a case study in mobile communications: Telecommunications Policy, v. 24, p. 305-321.

Katz, M. L., and C. Shapiro, 1986, Technology Adoption in the Presence of Network Externalities: The Journal of Political Economy, v. 94, p. 822-841.

KCC, 2008, KCC permits '010' prefix number for WiBro use .

KCC, 2011a, A Study on the Promotion Policy of WiBro Services in Korea Mobile Market, Broadcasting and Telecommunications Policy Research, KISDI.

KCC, 2011b, A Study on the Renewal and Pricing Policy for Radio Spectrums, Broadcasting and Telecommunications Policy Research, KISDI.

KCC, 2011c, Broadcasting & Telecommunications Industry Statistics Monthly Report (November 2011)

KCC, 2012, Decision on WiBro Policy Direction and Spectrum Renewal.

Kemp, R., J. Schot, and R. Hoogma, 1998, Regime Shift to Sustainability through Process of Niche Formation: The Approach of Strategic Niche Management: Technology Analysis & Strategic Management, v. 10.

Kim, D. H., and S. J. Lee, 2008, Mobile Communications Handsets, in S. Securities, ed., In-depth Report, Seoul, Korea.

Kim, D.-J., 2007, The process of international standardisation of WiBro: TTA Journal, v. 114, p. 44-52.

Kim, H. J., 2003, Fixed and Mobile Operators conflict over Portable Internet: Money Today.

Kim, H. S., 2003, KT and LG Group - SKT and Samsung, battle on Portable Internet, Digital Times, Seoul, South Korea.

Kim, M., J. Park, and J. Paik, 2014, The Causes of Low Market Diffusion of WiBro Service in Korea: ETRI Journal, v. 36, p. 490-497.

Kim, M. K., K. Y. Chi, and J. H. Park, 2006, Mobile Broadband in the Digital Convergence Era: Wibro and HSDPA : Journal of Communication and Networks, v. 23, p. 81-88.

Kim, N.-S., 2009a, WiBro Certification and Security (presentation in Korean), TTA.

Kim, S. H., 2012, WiBro Market Trend and Outlook and Policy Direction, Trends, KISDI.

Kim, T. J., 2005, Nortell attacks WiBro market through 'LG-Nortel', Digital Daily.

Kim, T. K., 2003b, 2.3GHz Portable Internet - A War without line, Information and Communications News (KOIT), South Korea.

Kim, W. B., 2004a, Posdata begins Portable Internet business, Electronic News, Seoul, South Korea.

Kim, W.-B., 2009b, Hyundai Heavy Industry Built up WiBro Network Enterprise-wide, Electronic News.

Kim, W. B., and J. H. Hwang, 2009, KT No plan for WiBro voice , Electronic News, Seoul, South Korea.

Kim, Y. H., 2009a, The current trends of WiBro business and future directions, in NARS, ed., NARS Pending Issue Report.

Kim, Y. H., 2009b, WiBro business trend and future directions , in NARS, ed., Pending Issue Report, Seoul, South Korea.

Kim, Y. S., 2004a, The meaning of Samsung-Intel collaboration over Portable Internet, ETNews.

Kim, Y. S., 2004b, Dacom gives up Portable Internet, Electronic News, Seoul, South Korea.

Kim, Y. S., 2004c, Telecommunciations operators - what do they have for 'WiBro', Electronic News, Seoul, South Korea.

Kim, Y. S., 2004d, Final decision on baseline of Portable Internet Standard , Electronic News, 3 February.

KISDI, 2004, Public Hearing on WiBro (Portable Internet) Licensing Policy, Seoul, South Korea, KISDI.

KISDI, 2011, Trends of Broadcasting and Communications Industry.

Ko, J.-S., 2004, KT's Portable Internet Introduction Strategy : Journal of the Korean Institute of Communication Sciences, v. 21.

Ko, J.-S., 2005, KT WiBro Business and Network Construction Plan: Telecom, v. 21.

KOIC, 5 January 2004, (New Year Special Edition) Portable Internet , Korea Information Communication.

Kwak, J. H., J. Y. Cho, Y. Lee, and B. G. Lee, 2011, Remaking Mobile Ecosystem Policies for New Mobile Market: Journal of Korean Society for Internet Information, v. 12.

Kwak, J., H. Lee, and V. V. Fomin, 2012, Government coordination of conflicting interests in standardisation: case studies of indigenous ICT standards in China and South Korea: Technology Analysis & Strategic Mangement, v. 23, p. 789-806.

Law, J., and M. Callon, 1992, The life and death of an aircraft: a network analysis of technological change, *in* W. E. Bijker, and J. Law, eds., Shaping technology/building society : studies in sociotechnical change: Cambridge, Mass. ; London, MIT Press, p. vii, 341 p.

Lee, B. K., J. H. Kwak, K. Y. Kim, and S. J. Kim, 2009, Technical innovation and 3.5 mobile phone generation: Lessons from Korea: Telecommunications Policy, v. 33, p. 296-308.

Lee, C. H., 2004, Portable Internet Standardisation and IPR : TTA Journal, v. 93.

Lee, E. Y., 2009a, Han Sun-Kyo, National Assembly Member insists to "Stop the domestic investment on WiBro", Electronic News, Seoul, Korea.

Lee, E. Y., 2009b, SKT launches Full Touch WiBro Phone , Electronic News, Seoul, South Korea.

Lee, G. S., 2003, 2.3GHz Portable Internet, conflicts sharpening, expecting difficulties in policy decision: iNews .

Lee, H., and S. Oh, 2008, The political economy of standards setting by newcomers: China's WAPI and South Korea's WIPI: Telecommuniactions Policy, v. 32, p. 662-671.

Lee, H. W., 2004, Liaison Letter from TTA to IEEE802.16 on 12 January 2004, TTA.

Lee, J. H., 2011, Issues and Future Outlook regarding Domestic Three Mobile Operators' Choice upon LTE and WiBro, KTOA.

Lee, J. H., 2012, Pyo Hyun Myung, President of KT says "WiBro Spectrum needs transition to LTE", Chosun Ilbo.

Lee, J. H., S. B. Moon, J. W. Joo, S. H. Na, K. S. Oh, and H. Chung, 2011a, A Study on the Telecommunications Policy for the New ICT Ecosystem, in KCC, ed., KISDI.

Lee, K. S., 2003, POSDATA strengthens ICT business, inews24, Seoul, South Korea.

Lee, S.-Q., N. Park, C. Cho, H. Lee, and S. Ryu, 2006, Evolving Toward Next Generation Wireless Broadband Internet, in V. N. Alexandrov, G. D. van Albada, P. M. A. Sloot, and J. Dongarra, eds., Computational Science - ICCS 2006, Reading, UK, Springer.

Lee, T. H., 2003b, 'SK-KT: War of nerves over Portable Internet', Munhwa Ilbo, Seoul, South Korea.

Lee, Y. S., J. R. Chung, S. H. Park, and S. W. Kim, 2011, A Study on Policies for the Activation of WiBro Market: Korea System Dynamics Research, v. 12, p. 37-67.

Lindmark, S., E. Bohlin, and E. Andersson, 2004, Japan's mobile internet success story - facts, myths, lessons and implications: info, v. 6, p. 348-358.

Lyall, C., and J. Tait, 2005, New Modes of Governance: Developing an Integrated Policy Approach to Science, Technology, Risk and the Environment: Hants, Ashgate.

Lyytinen, K., and J. Damsgaard, 2001, What's Wrong with the Diffusion of Innovation Theory: The Case of a Complex and Networked Technology: IFIP Working Group 8.6 Conference.

Lyytinen, K., and J. L. King, 2006, Standard Making: A Critical Research Frontier for Information Systems Research: MIS Quarterly, v. 30, p. 405-411.

MacKenzie, D. A., and J. Wajcman, eds., 1985, The social shaping of technology : how the refrigerator got its hum: Milton Keynes, Open University Press, viii, 327 p. p.

Marks, R. B., 2004a, Letter response from IEEE 802.16 Working Group to TTA PG05 on 15 January 2004, IEEE.

Marks, R. B., 2004b, Liaison letter from IEEE 802.16 WG to TTA PG302 on 20 May 2004, in TTA-PG302, ed.

Menanteau, P., and H. Lefebvre, 2000, Competing technologies and the diffusion of innovations: the emergence of energy-efficient lamps in the residential sector: Research Policy, v. 29, p. 375-389.

MIC, 2001a, Research on the efficient use of 2.3GHz frequency band spectrum .

MIC, 2001b, Research on the ways of efficient use of 2.3GHz frequency band spectrum , in M. O. I. A. Communication, ed.

MIC, 2002, Research on the Use of 2.3GHz and 5GHz frequency band , in M. O. I. A. Communication, ed.

MIC, 2003, Research on the Spectrum Use for Portable Internet and Mobile Communications, in M. O. I. A. Communication, ed.

MIC, 2004, WiBro (Portable Internet) Licensing Policy Scheme.

MIC, 2005, Introduction and Promotion of Portable Internet (WiBro) Service .

MIC, 2006a, Information and Telecommunication Whitepaper , Ministry of
    Information and Communication.

MIC, 2006b, WiBro (Portable Internet) World's First Commercial Service Launch .

MIC, 2008, WiBro Licensing Policy Measure, Ministry of Information and
    Communication, South Korea.

Miles, M. B., and A. M. Huberman, 1994, Qualitative Data Analysis, 2nd Ed.:
    Newbury Park, Sage Publications.

Mitchell, J. C., 1983, Case and situation analysis: Sociological Review, v. 31, p.
    186-211.

Molina, A. H., 1997, Insights into the nature of technology diffusion and
    implementation: the perspective of sociotechnical alignment: Technovation,
    v. 17, p. 601-626.

Moon, S. B., J. Lim, J. W. Ju, J. W. Kwak, N. S. Kim, D. Y. Yoon, A. Choi, R., and
    E. M. Shim, 2011, A Study on the Structure of Smart Ecosystem and the
    Regulatory Framework, in KCC, ed., Broadcasting and Telecommunications
    Policy Research, KISDI.

MSIP, 2013, MSIP decides on WiBro Policy Direction.

Nicoll, D. W., 2000, Users as Currency: Technology and Marketing Trials as
    Naturalistic Environments: The Information Society, v. 16, p. 303-310.

Oshri, I., and C. Weeber, 2006, Cooperation and Competition Standards-Setting
    Activities in the Digitization Era: The Case of Wireless Information Devices:
    Technology Analysis and Strategic Management, v. 18, p. 265-283.

Paik, J. H., M. K. Kim, and J. H. Park, 2009, A Study on the Causes of WiBro's Poor
    Performance and the Factors in 4G Global Market Success (in Korean;
    Abstract in English): Samsung SDS Journal of IT Services, v. 7.

Park, C.-K., 2005, KT WiBro Business and Network Construction Plan: Journal of
    Internet Computing and Services, v. 6.

Park, J. H., 2008, Characteristics of WiBro Subscribers and Market Strategy in Fixed
    and Mobile Convergence: Electronic Telecommunications Trends Analysis,
    v. 23.

Park, J. H., J. M. Kim, M. K. Oh, D. S. Lim, and H. S. Ham, 2010, Convergence
    between Ship Industry and IT towards the Best of Best in the Global Ship
    Industry, Weekly Technology Trends, NIPA.

Park, J. H., and M. G. Kim, 2008, WiBro Global Strategy , in ETRI, ed.

Pinch, T., and W. Bijker, 1984, The social construction of facts and artifacts: Or how the sociology of science and the sociology of technology might benefit each other: Social Studies of Science, v. 14, p. 399-444.

Radha, G. S. V., K. Rao, and G. Radhamani, 2008, WiMAX: A Wireless Technology Revolution: Boca Raton, FL, Auerbach Publication.

Rapley, T. J., 2001, The art(fulness) of open-ended interviewing: some considerations on analysing interviews.: Qualitative Research, v. 1, p. 303-323.

Ribes, David and Polk, Jessica Beth. 2014. *Flexibility Relative to What? Change to Research Infrastructure* Journal of the Association for Information Systems 15 (5)

Rip, A., T. J. Misa, and J. Schot, 1995, Constructive Technology Assessment: A New Paradigm for Managing Technology in Society, *in* A. Rip, T. J. Misa, and J. Schot, eds., Managing technology in society : the approach of constructive technology assessment: London, Pinter.

ROA, 2008, WiBro Services and Strategies in South Korea, Research on Asia Group.

Rip, A., and J. W. Schot, 2002, Identifying *Loci* for Influencing the Dynamics of Technological Development, *in* K. H. Sørensen, and R. Williams, eds., Shaping technology, guiding policy : concepts, spaces, and tools: Cheltenham ; Northampton, MA, Elgar, p. xiv, 404 p.

Rogers, E. M., 1962, Diffusion of innovations: New York, Free Press of Glencoe.

Rotmans, J., and R. Kemp, 2001, More evolution than revolution: transition management in public policy: Foresight, v. 3, p. 15-31.

Rubin, H. J., and I. Rubin, 1995, Qualitative interviewing : the art of hearing data: Thousand Oaks ; London, Sage, viii, 302 p p.

Russell, S., and R. Williams, 2002, Concepts, Spaces and Tools for Action? Exploring the Policy Potential of the Social Shaping Perspective, *in* K. H. S²rensen, and R. Williams, eds., Shaping technology, guiding policy : concepts, spaces, and tools: Cheltenham ; Northampton, MA, Elgar, p. xiv, 404 p.

Samsung Electronics Co., L., 2012, Timing the Move to TD-LTE, Suwon, Gyeonggi-do, South Korea.

Schot, J. W., 1992, Constructive Technology Assessment and Technology Dynamics: The Case of Clean Technologies: Science, Technology, & Human Values, v. 17, p. 35-56.

Schot, J., and F. W. Geels, 2007, Niches in evolutionary theories of technical change: Journal of Evolutionary Economics, v. 17, p. 605-622.

Schot, J., and F. Geels, 2008, Strategic niche management and sustainable innovation journey: theory, findings, research agenda, and policy: Technology Analysis & Strategic Management, v. 20, p. 537-554.

Schot, J., and A. Rip, 1997, The Past and Future of Constructive Technology Assessment: Technological Forecasting and Social Change, v. 54, p. 251-268.

Seo, J.-R., 2004, SK Telecom's Portable Internet Business Plan: The Journal of Korea Information and Communications Society, v. 21.

Seok, W. H., K. S. Lee, and Y. K. Song, 2011, Current Status and Prospect of WiBro market: Electronics and Telecommunications Trends, v. 26.

Shin, D.-H., 2006a, Prospectus of mobile TV: Another bubble or killer application?: Telematics and Information, v. 23, p. 253-270.

Shin, D.-H., 2006b, Socio-technical challenges in the development of digital multimedia broadcasting: A survey of Korean mobile television development: Technological Forecasting and Social Change, v. 73, p. 1144-1160.

Shin, D.-H., H. Choo, and K. Beom, 2011, Socio-Technical Dynamics in the Development of Next Generation Network: Translation Beyond 3G: Technological Forecasting & Social Change, v. 78, p. 514-525.

Silverstone, R., and L. Haddon, 1996, Design and the Domestication of Information and Communication Technologies: Technical change and everyday life, *in* R. Mansell, and R. Silverstone, eds., Communication by design : the politics of information and communication technologies: Oxford, Oxford University Press, p. xiv, 278p.

Smith, A., A. Stirling, and F. Berkhout, 2005, The governance of sustainable socio-technical transitions: Research Policy, v. 34, p. 1491-1510.

Smith, A., J.-P. VoB, and J. Grin, 2010, Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges: Research Policy, v. 39, p. 435-448.

Song, J.-Y., P.-Y. Joo, and Y.-K. Kim, 2006, Process toward the making of WiBro-International standard: TTA Journal, v. 103, p. 191-194.

Song, S. I., Y. I. Kim, and Y. J. Kim, 2003, High-Speed Portable Internet Technology Implication: Electronic Telecommunication Trends Analysis, v. 18.

Song, W. J., 2003, Severe competition for the throne of Portable Internet , ZDNet Korea, 20 May.

Song, W., and J. Lee, 2007, Response to technological and economic uncertainties in the post-catching stage: The development of a conceptual framework : Journal of Science and Technology Studies, v. 7, p. 5-31.

Song, W., D.-o. Park, and Y.-j. Kang, 2007, Managing Techno-economic Uncertainties in the Post catch-up stage, Science and Technology Policy Institute

Song, W. J., 2004, Portable Internet, not enough with only HPi, ZDnet Korea, 30 March.

Sørensen, K. H., 1996, Learning technology, constructing culture: Socio-technical change as social learning, STS Working paper, Trondheim, University of Trondheim: Centre for Technology and Society.

Spencer, L., J. Ritchie, and W. O'Connor, 2003, Analysis: Practices, principles and processes, in J. Ritchie, and J. Lewis, eds., Qualitative research practice: A guide for social scientist students and researchers.

Stake, R. E., 1998, Case studies, in N. K. Denzin, and Y. S. Lincoln, eds., Strategies of qualitative inquiry: Thousand Oaks, Calif. ; London, Sage, p. xxii, 346p.

Stewart, J., 2005, Context Perspectives for Scenarios and Research Development in Mobile Systems, in L. Hamill, and A. Lasen, eds., Mobile World: Past, Present and Future, Springer, p. 161-194.

Stewart, J., and S. Hyysalo, 2008, Intermediaries, Users and Social Learning in Technological Innovation: International Journal of Innovation Management, v. 12, p. 295-325.

Stewart, J., and R. Williams, 2005, The Wrong Trousers? Beyond the Design Fallacy: Social Learning and the User, in H. Rohracher, ed., User Involvement in innovation processes: Strategies and limitations from a socio-technical perspective: Munich, Profil-Verlag.

Suh, J. H., and R. Williams, 2013, Standardisation: a configurable space for the distributed governance of innovation, Research provocation for IFRIS/DIM IS2-IT International Workshop; Standardization as space(s) for innovation, Champs-sur-Marne, France.

Tassey, G., 2000, Standardization in technology-based markets: Research Policy, v. 29, p. 587-602.

Tilson, D., and K. Lyytinen, 2006, The 3G transition: Changes in the US wireless industry: Telecommunications Policy, v. 30, p. 569-586.

TTA, 2006, Standardization Roadmap for IT839 Strategy.

TTA, 2008, Cases of ICT Standardisation in South Korea - Appendix 4 , Handbook of Information and Communication Standardisation 2008 .

Turner, B. A., 1981, Some practical aspects of qualitative data analysis: one way of organising the cognitive processes associated with the generation of grounded theory: Quality and Quantity, v. 15, p. 225-47.

USTR, 2004, Results of 2004 Section 1377 Review of Telecommunications Trade Agreements, in T. O. o. U. S. T. Representative, ed., USTR, p. 1-13.

Van De Ven, A. H., 2005, Running in packs to develop knowledge intensive technologies: MIS Quarterly, v. 29.

van Lieshout, M., W. Bijker, E., and T. M. Egyedi, eds., 2001, Social learning technologies: the introduction of multimedia in education, Aldershot: Ashgate.

von Hippel, E., 1986, Lead users: A Source of Novel Product Concepts: Management Science, v. 32.

von Hippel, E., 2005, Democratizing Innovation: Cambridge, MassachusettsLondon, England The MIT Press.

Ward-Schofield, J., 1993, Increasing the generalisability of qualitative research, in M. Hammersley, ed., Social research: Philosophy, politics & practice: London, Sage publications.

Warren, C., 2002, Qualitative Interviewing, in J. F. Gubrium, and J. A. Holstein, eds., Handbook of Interview Research: Context and Method: Thousand Oaks, CA, Sage Publications.

Williams, R., 2000, Public Choices and Social Learning: The New Multimedia Technologies in Europe: The Information Society, v. 16, p. 251-262.

Williams, R., 2006, Compressed Foresight and Narrative Bias: Pitfalls in Assessing High Technology Futures: Science as Culture, v. 15, p. 327-348.

Williams, R., R. Bunduchi, I. Graham, and N. Pollock, 2004, Understanding the Evolution of Standards: Alignment and Reconfiguration in Standards Development and Implementation Arenas: 4S & EASST.

Williams, R., and D. Edge, 1996, The social shaping of technology: Research Policy, v. 25, p. 865-899.

Williams, R., R. Slack, and J. Stewart, 2000, Social Learning in Multimedia - Final Report, RCSS, University of Edinburgh.

Williams, R., J. Stewart, and R. Slack, 2005, Social learning in technological innovation : experimenting with information and communication technologies: Cheltenham, Edward Elgar Publishing, xii, 270 p. p.

WiMAX-Forum, 2006, The Relationship Between WiBro and Mobile WiMAX, in http://www.wimaxforum.org/news/WiBro_and_Mobile_WiMAX_Backgrou nder.pdf, ed.

WiMAX-Forum, 2012, WiMAX Forum Newsletter (November 2012).

Woolgar, S., 1991, Configuring the user: the case of usability trials, *in* J. Law, ed., A Sociology of monsters : essays on power, technology and domination: London, Routledge, p. 57-102.

Xavier, P., 2001, Licensing of Third Generation (3G) Mobile: Briefing Paper, ITU Workshop on licensing 3G Mobile, Geneva.

Yeo, J. H., 2012, Next-generation Mobile Communications Network and Spectrum Policy Direction, in KISDI, ed., KISDI Premium Report.

Yeo, J. H., and D. W. Park, 2010, Outlook on the advancement of mobile communications network and the policy direction - focusing on the evolution of LTE, in KISDI, ed.

Yin, R. K., 2009, Case study research : design and methods Applied social research methods series ; v. 5: Thousand Oaks, CA, Sage, xvii, 171 p p.

Yoo, Y., K. Lyytinen, and H. Yang, 2005, The role of standards in innovation and diffusion of broadband mobile services: The case of South Korea: Strategic Information Systems, v. 14, p. 323-353.

Yoon, C.-B., 2004, Telecommunications Market and Portable Internet Business, Electronic News, Seoul, South Korea.

Yoon, I. J., N. H. Kim, and S. H. Choi, 2007, Global WiBro Market Outlook & Feasibility Study for Overseas Projects , in H. I. o. Finance, ed., Industry Research Series, Seoul, South Korea.

Yoon, J.Y., 2011, Bid for fourth mobile carrier shot down, The Korea Times.