Intellectual Property in Broadband Mobile Telecommunications: Predictions on 4G WiMAX

by

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Abstract

The conflict between intellectual property rights and standardization has become clearly visible with the examples of the second generation (2G) wireless GSM system and the third generation's (3G) WCDMA and CDMA-2000 systems. Now, on the verge of standardizing fourth generation (4G) systems, the mobile telecommunications industry has become highly sensitive to issues resulting from the ownership of a standard's essential patents. Mobile WiMAX, which is expected to form part of future 4G systems, is said to be offering a vendor-neutral patent landscape since it is based on new radio access technology, allowing no company to leverage its existing position into WiMAX. Based on the theoretical and historical context of IPRs in mobile telecommunications, this paper establishes a framework encompassing six factors to evaluate the role of IPRs in broadband mobile telecommunications. The factors include analyses of the number of essential patents, the patents' fragmentation and the business models of the involved companies. This framework is applied to analyze the present IEEE 802.16e-2005 (4G WiMAX) standard, and the findings suggest that the supporting arguments may turn out counterproductive with WiMAX suffering from high transaction costs as well as weak competitiveness.

About this paper

This paper is based on a master's thesis which has been written at the MAS Intellectual Property at the Swiss Federal Institute of Technology in Zurich. The complete thesis including all detailed references is available at http://www.bepress.com/ndsip/papers/

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1. Introduction

The second (2G) and third generation (3G) of mobile telecommunications have provided excellent examples of the deep tension between intellectual property rights (IPRs) and standardization. While this issue has always been on the agenda of industry and IP scholars, special characteristics of the mobile telecommunication market have amplified this tension and made the "IPR question" a decisive factor for future mobile systems.

Now, industry has begun to standardize 4G systems, intended as a "converging" technology, which combines the wireless communication world and the internet world. One of 4G's expected radio access technologies is "Mobile WiMAX", which has been standardized in IEEE 802.16e-2005[1] (4G WiMAX). This paper addresses the question of the role IPRs in this new generation of broadband mobile technologies. This paper summarizes factors which have turned out to be of high significance for standardized technologies in general and 2G and 3G systems in particular, and maps this framework to analyze 4G WiMAX. I conclude that the striking argument of WiMAX's supporters that its technological basis on OFDMA as a new radio access technology (compared to TDMA or CDMA as in former standards) is likely to turn out counterproductive and WiMAX will be plagued by a very thorny patent thicket: High fragmentation among the holders of IPRs, the dominance of vertically-integrated companies and the existing presence of upstream companies will lead to high transaction costs and weak competitiveness.

2. The Role of IP in Complex Industries

In 1998, Heller published two significant papers examining the "tragedy of the anticommons", based, inter alia, on a case study about empty stores in Moscow while streets full of thousands of metal kiosks flourished,[2] and later addressing patents in biomedical research. Prior to Heller's analyses, the "tragedy of the commons" was known as the issue of too many people jointly owning access to a specific, limited resource; no one having the right to exclude another, and thereby leading to overuse of said resource (fishing in the seas leading to dying out of species is one of the mostly used examples). Heller explained the "tragedy of the anticommons" as a situation "where multiple owners each have a right to exclude others from a scarce resource and no one has an effective privilege of use." Applied to biotechnology, the "spiral of overlapping patent claims in the hands of different owners" has the potential to create a situation where "[e]ach upstream patent allows its owner to set up another tollbooth […] adding to the cost[,] and slowing the pace of downstream biomedical innovation."[3]

Extending Heller's idea, in 2001, Shapiro introduced the idea of a "patent thicket": a "dense web of overlapping intellectual property rights, [that…] can have the perverse effect of stifling, not encouraging, innovations," which is especially dangerous in standards-dependent industries like telecommunications: First, by referring to Cournot's "complements problem" from 1838, he reveals that distributed monopoly power, i.e., each company exclusively controlling one good, is more harmful to consumers and producers than one single supplier's monopoly over all goods. Second, he points to the danger of "step[ping] on a land mine". This is referred to as the "hold-up" or "holdout" issue: Patentees wait until a standard is set and compatible products manufactured using their patents, and ex post, demand negotiations for high royalty payments, thereby additionally increasing transaction costs and burdening innovation.[4]

Both Heller and Shapiro describe how a vast number of complementary patents in the hands of many different patentees (i.e. a highly fragmented patent landscape) and within this landscape, companies focused on IP income generation, can jeopardize innovation, in particular in standards-driven industries like mobile telecommunications.

However, on the other side of the coin, there are scholars who perceive a different situation: The market and the legal instruments enable IPRs to foster instead of jeopardizing innovation, which is also the case for standards-driven industries.

For instance, in 2004, Epstein and Kuhlik argued against the anticommons in the domestic field of biomedical research, positing that Heller and Eisenberg "have overstated the case against

patent protection". They suggest that it is in patent owners' interests to recapture the investment in their patent, especially when one takes into account the limiting factors of time, competing patents and new technologies; they propose that "[t]hose who will not deal, will not prosper."[5]

Similarly, Ziedonis finds that the market already provides a successful answer to highly fragmented patent landscapes. While empirically analyzing the semiconductor industry from 1980-1994, she shows that fragmentation is the driving factor for an organization to increase its own patenting activities. To avoid being "fenced in", companies "acquire patents more aggressively than otherwise expected when markets for technological inputs are highly fragmented." Following her line of argumentation, increased patent ownership does not primarily increase royalty stacking effects, but rather fosters cross-licensing which again has positive effects on innovation.[6]

Finally, in a 2006 paper, Geradin and Rato exhaust the conflict of IP standardization and competition law and clearly advise against loosening IPR protection as implied by scholars like Heller and Shapiro. In one example, they deal with the consequences for a company having made a (F)RAND commitment during a standardization process: If this commitment meant that the patentee thereby renounced its right to apply for injunctions (the so-called "waiver theory"), the patentee would be in a weak position since he has no effective means for enforcing his right to a reasonable royalty, and, thereby he would have to accept low and non-(F)RAND compliant royalties in order to avoid going through lengthy and expensive court-proceedings, a situation they call an "inverse patent hold-up."[7]

To put in a nutshell, following the line of argumentation as provided by this group of scholars, they offer the question of whether at the end of day, if patentees' received royalty rates, whether negotiated or obtained by court, have diminished to such an extent that it is not worth the effort of taking risk and undergoing investment – what is the value of a patent system?

3. Experiences of the Mobile Telecommunication Industry

With the establishment of 2G (TDMA based) GSM in Europe in the late 1980s, the telecommunication industry experienced a "serious clash between IPRs and standardization,"[8] forming the starting point for the "painful history of GSM patent licensing [which] left a lingering resentment within the industry."[9] Besides loosing the romantic idea of reaching generous "Gentlemen's Agreements"[10], the industry also spent more than five years on finding a binding IPR policy[11]. And, even worse, in 1998, the ITSUG authored a complaint to the European Commission in which it summarized the GSM licensing problems in stating that the inability to

acquire timely licenses coupled with the uncertainty of essentials lead to "costly and complex licensing negotiations" and "excessive cumulative royalty rates", thereby creating substantial transaction costs and high barriers to entry to the GSM market. In addition, the ITSUG alleged the existence of "a low/zero club for established European telecommunications players" [12], while others have to pay royalties up to 40% of the ex-works selling price.[13] Proof of this alleged "closed market" is found on terminal devices, as it took several years, until Asian and American companies succeeded in obtaining licenses enabling them to capture "some part of this huge market".[14]

Almost ten years later, in 2007, FAIRFIELD RESOURCES INTERNATIONAL presented an analysis of "declared" and "judged" essential patents for the GSM standard. The analysis found 554 patent families declared essential to GSM, among which only 149 patents, i.e., 27%, were judged essential by technical experts. Whereas many companies have declared to own essential IPR, taking into account their shares, fragmentation appears very low: Four companies (NOKIA, MOTORALA, ERICSSON, QUALCOMM) hold 74% of the declared essential families; in addition, the first three possess 75% of the judged essential patents.[15]

In contrast to the heavily disputed GSM standard, other 2G standards have not created so much debate about IPRs. For example, in the US, CDMA based technologies evolved, and these were heavily dominated by QUALCOMM. With comparably lower fragmentation and the dominance of an upstream company, CDMA based standards did not seem to suffer the royalty stacking issues as described in the ITSUG's complaint.

While the need for more applications drove technical development towards 3G, IPR considerations formed part of the dominating strategies. The evolutionary developments from 2G to 3G made it unfeasible to agree on a unique air interface; in fact, the ITU had to standardize five interfaces, whereby each 3G technology has evolved from one or more 2G technologies: While existing GSM systems led to the establishment of WCDMA, CDMA based standards resulted in CDMA2000; China pursued its own technological development referred to as TD-SCDMA, to reduce dependency from Western technology. However, the companies' contributions became so mixed that related IP finally created an "ill-fitting jigsaw puzzle."[16]

To eliminate the problems that burdened GSM, the UMTS IPR Group proposed in January 1999 to set up a "Patent Platform", which aimed to strike a balance between a rather rigid "Patent Pool" and completely free bilateral negotiations. Among its core paradigms, the Group proposed that the platform should retain the flexibility of individual bilateral licenses, while the participants should agree on a common evaluation mechanism and a maximum cumulative

royalty rate.[17] This time, the US Department of Justice (DOJ) demanded that each individual 3G technology must be governed by an independent Platform Company, explicitly referring to potential inter-technology competition. However, as of the date of this paper and to the knowledge of the author, the only existing 3G patent platform is the "3G Licensing – W-CDMA Patent Licensing Programme," encompassing twelve companies, holding altogether 188 W-CDMA essential patents. It offers "Standard License Agreements" for five different product categories and a "Joint License Agreement" for handsets, having set the "maximum cumulative royalty" for different categories of 5.0% of the net sales value.[18]

In 2005, Goodman and Myers presented their evaluation of 3G relevant patents.[19] Their startling analysis showed a huge gap between patents "declared essential", and patents "judged essential" by their technological experts. First, they showed that for both major standards, 3GPP (WCDMA) as well as 3GPP2 (CDMA2000), "nearly 80% of the patents declared essential are probably not essential for practicing the standard," i.e., out of 732 patent families for WCDMA, the experts judged only 157 as being essential.[20] Second, they showed that for WCDMA, "[a]lthough the patents declared essential are assigned to 41 companies, the patents judged essential are assigned to 20 companies." Their findings were particularly negative for QUALCOMM, in that they showed that it is not dominating the WCDMA standard, rather QUALCOMM stands number three, behind the vertically integrated NOKIA and ERICSSON.

However, this report did not remain without a response from QUALCOMM's external advisors Martin and De Meyer, published one year later. They accurately analyzed all limitations of the study and attacked the informative value of the findings since "simple patent counting […is] a poor predictor of patent valuation". To make their point clear in simple words, they ask: "If all parts of a car were covered by patents, would the ashtray or the windshield wipers command the same royalty as the engine or the gearbox?"[21]

To evaluate the impacts of the 3G patent thickets, in particular in comparison with the 2G GSM issues, there is still a lot of uncertainty: CREDIT SUISSE FIRST BOSTON (CSFB) published a detailed market report, substantially based on IPRs, in particular on the analysis by Goodman and Myers, which assumes for WCDMA from 2005 to 2010 an average royalty rate of "17.3% for those vendors without an IPR position to trade off", which is still far beyond average royalty rates as known before the take-off of GSM.[22] But once again, there is another side: Geradin et. al concluded in 2007 that there is "no evidence of a significant royalty stacking in the 3G telecoms industry". Besides statistical methods, they make out three factors which are necessary (but not sufficient) for royalty stacking: (1) complementary instead of substitutable

patents, (2) a high number of patents required for one product, and (3) high fragmentation. According to their report, 86% of all essential patents' prior art listings are held by four companies. Consequently, they state that the requirement of high fragmentation is unmet. [23]

After all, business reality might have shown the truth: APPLE's late but successful release of its IPHONE shows that there is still a highly competitive market which does not suffer from insuperable barriers to entry. While not owning "essential" IPRs, APPLE launched– in 3G's upturn phase – a 2.5G phone with a focus on other convincing aspects, like design and UI. Similarly, RIM succeeded with its BLACKBERRY handheld device several years earlier.

4. 4G WiMAX

Although there is not (yet) a single accepted definition relating to 4G, the most commonly shared idea consists of the idea of enabling wireless network access to different networks, in particular to the Internet "anytime, anywhere, and at a wide range of speeds"[24]. Irrespective of where the user is located, whether sitting at home or traveling in a high speed train, he always has access to the right mobile connection for all his needs, including broadband Internet, voice services, GPS services, etc.

Figure 1 provides an overview of 4G's role: It should not be understood as a specific standard, or a set of competing standards, rather it provides a "network of networks", including at its core new radio access networks like "WiMAX". However, 4G refers to a heterogeneous rather than a homogeneous network, being built out of a fusion of existing and newly developed elements.[25]

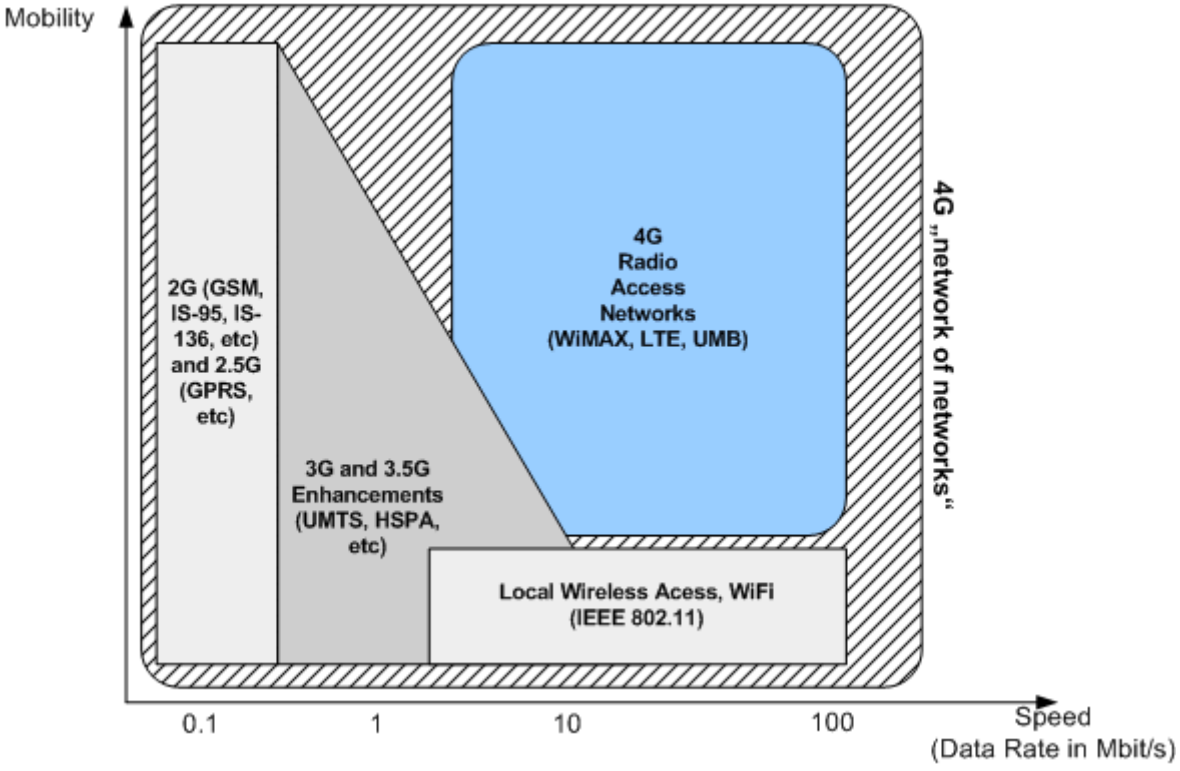

Figure 1: Radio access networks and the role of 4G [26]

The ITU intends to define 4G within its IMT-Advanced process by 2009, expecting the deployment starting commercially in 2011. It is expected that several air interfaces will become part of the 4G definition, besides WiMAX, in particular LTE (3GPP's WCDMA successor) and 3GPP2's successor UMB, as both underlying technologies are already part of the IMT-2000 framework. [27]

To clarify, when referring to "WiMAX", this report refers to "Mobile WiMAX", as standardized in IEEE 802.16e-2005. It is implemented as extension to the "fixed WiMAX" (IEEE 802.16-2004) standard, however, it aims at full mobility and is therefore "4G's WiMAX". While many features of the older "fixed" version are present in the newer mobile version, e.g., the OFDMA implementation, more features have been added for mobile WiMAX, e.g., like the requirement of handover.

While in the subsequent section this paper establishes a general evaluation framework for broadband mobile telecommunications, the empirical analysis in Section 4 is restricted solely to WiMAX as 4G's radio solution. Several indicators suggest WiMAX being successfully deployed in future.[28]

5. IPRs in New Broadband Mobile Telecommunications

With the aforementioned theoretical, historical and technical background in mind, this section constructs a 4G patent evaluation framework which is used to analyze the effects of royalty stacking and burdened innovation, or, respectively, the establishment of improvements compared to former standards' problems and the creation of certainty and incentives to invest. This framework is partly based on Geradin et. al's factors from 2007 comprising (1) complementary instead of substitutable patents, (2) the number of patents, and (3) fragmentation, but it goes further and takes (4) the business model of the involved player into account. [29]

The first factor that fosters the risk of royalty stacking is the issue of **complementary patents without substitutes**. While usually a company's single patent does not block competitors in complex industries, the situation changes when there is no substitute, i.e., a specific patent cannot be designed around as it has become an "essential" patent within a given standard. Accepted theories suggest that before a standard is set (ex ante), there is substitutability, while afterwards (ex post), there is only a long list of complementary "essentials", all required to implement the standard. Even though this is a simplification in many ways[30], it should be

accepted that all standardized mobile technologies consist of the same degree of complementary, irreplaceable patents.

The second critical factor consists in the **number of patents**. While it is usually obvious that a huge number of patents fosters the risk of significant transaction costs and royalty stacking, there is an interesting argument to dispute this fateful relationship: Lichtman argues that a high number of patents accompanied with a high share of fragmentation is beneficial for reducing the risk of holdouts and high royalties.[31] Primarily, Lichtman's argument is more dependent on fragmentation rather than on sheer numbers; but furthermore, he ignores some dynamics, i.e., that only if all participants follow non-royalty based business models can the scheme work.[32] However, if some companies (have to) rely on income generated by IP royalties, they will not behave as Lichtman predicts which may result in an unpleasant situation; more likely, concentration in the IP market will take place, e.g., by patentees joining together and forming a unified pool,[33] or through the appearance of patent holding companies. Hence, despite Lichtman's argument, the higher the number of patents, the higher the risk of a "thorny" patent thicket.

A third factor, as discussed with respect to 2G and 3G, looks to patents **fragmentation**. In addition to the above rejection of Lichtman's argument in favor of fragmentation, Shapiro shows that high fragmentation creates in particular two dangerous effects: (1) receiving licenses from dozens of players has higher transaction costs over "one-stop-shopping" (or at least a "few-stop-shopping"), and (2) the more players that are involved, the higher the risk that there are holdouts. As outlined above, Ziedonis demonstrates that a functioning market offers companies the best answer to increased fragmentation by increasing their own patenting activities. This principle of "cause and effect" may apply for future developments (and Ziedonis makes use of backwards citations) but with respect to evaluating broadband mobile standards the dispersion of essential IPR is inseparably connected to the expected transaction costs, as can be seen for GSM.[34]

These considerations point to a fourth factor: the **patent owners' business models**. The original GSM standard was primarily covered by patents of vertically integrated holders; it took years until foreign manufacturers could enter this "closed" market. Upstream companies, in particular QUALCOMM, play an important role in WCDMA, leading arguably to higher licensing costs, but also to a more competitive downstream market. Companies pursuing conflicting interests (as depicted in Table 1), and situations which benefit one patentee may have drawbacks for others. The following evaluation will analyze the influence of the different players, drawing conclusions on the efficiency of 4G WiMAX.

Type[35]	Dominating Interests
Upstream	Maximum IPR revenues, i.e. maximise the product of number of agreements and rate per agreement
Vertically integrated	Protection against "outsiders" Lower costs than competitors
"Outsider" / Manufacturer	Lowest IPR costs
Buyer / Service Provider	Low IPR costs Competitive manufacturing market

Table 1: Dominating IP based interests of major business models

The results of the above factors will be given values in the next section and are finally weighed in the conclusion. Based thereon, this paper draws implications for IP's role in 4G WiMAX in particular and broadband mobile telecommunications in general.

6. Analysis of 4G WiMAX

As discussed, **complementary and non-substitutable patents** must ex post be regarded with the definition of "essential" patents[36]: To make this report more straightforward, it is (realistically) assumed that there is no significant difference between former 2G or 3G standards and 4G WiMAX with regard to the degree of complementary and non-substitutable patents.

Turning to the second factor, the **number of essential patents**, it has always been difficult to establish a complete list for one specific standard[37], let alone the issue of evaluated essentials. At the time this paper is written, it is just impossible to provide a complete declared list for WiMAX, since the present IEEE's IPR policy does not require specific disclosure. Syputa, a frequently quoted analyst from a broadband wireless research institute, posits that there are 550 essential (single) patents for WiMAX and – in total – 320 judged essential patent families for WiMAX, LTE and UMB.[38] As of August 1, 2007, 34 different companies have made declarations to the IEEE (20 of those companies provided a "Blanket Letter of Assurance", 11 having issued a "Letter of Assurance" including the disclosure of specific patent numbers, 3 companies did both). Aggregating all specific disclosures, the 14 companies have furnished 337 patents, patent applications and filed applications – for IEEE 802.16 and its amendments.[39] These single patents result in 152 patent (and application) families[40]. Consequently, if patents were equally distributed among "specific disclosers" and those providing blanket letters, 370 patent families would be listed.

As there are more reasons for companies to overstate their portfolios than to hide patents from the SSO, a question as to the scope of "real" essentials remains. Goodman and Myers have

shown the existence of a wide gap between declared essentials and judged essentials which remains undeniably true irrespective of all valid criticisms.[41] On the basis of their three analyses, they detect values for the ratio of declared to evaluated essentials of approximately 25%. In contrast, 3G LICENSING's published numbers of judged WCDMA essential patents through their professional evaluation mechanism are significantly higher, about three times as high as Goodman and Myers figures.[42]

The question with respect to the number of essential patents cannot be answered statistically with a concrete number, but rather with two important conclusions: First, the initial version of Mobile WiMAX shows significantly fewer patents declared essential than later versions of GSM and WCDMA, whereby the number is likely to increase over time. Second, even though WiMAX essentials may only constitute a small fraction of the IP required of future converging "4G devices", this fraction may become the decisive one: Many other parts do not suffer the standardized "unsubstitutability" problem, like e.g., user interfaces, and, moreover, among the standardized blocks, no royalty market has undergone a development like the mobile telecommunications IP market, leading to a several billion $ turnovers per year on which companies heavily rely[43]. As a result, within a 4G device, the group of patents required for mobile WiMAX (or any other interface) may not form the highest number, but may, in point of fact, constitute the most expensive group.

It is necessary to establish the dispersion of the mobile WiMAX relevant IPR to evaluate **fragmentation** and the impact of various business models. The absence of a publicly available complete list of "essentials" as well as the inability to judge single patents out of thousands of patents with respect to their true essentiality forecloses the use of some well-known 2G and 3G analytic methods. Moreover, long time periods from filing to grant hamper precise analysis of fast-growing technologies in early stages, such as WiMAX at the time of this paper: For example, at the European Patent Office the average time from filing to grant was 44.3 months in 2006[44], plus 12 months priority for many patents, i.e. most patents granted in 2006 were for inventions made in 2001.[45]

Thus, this paper takes into account all granted patents and applications as filed, and uses a method called the "probability approach" which is accomplished through a four-part analysis. First, all 337 specifically disclosed patents and patent applications are examined, and their corresponding 152 patent families isolated. Second, since the companies that disclosed specific patent numbers are mixed with regard to their business (network, handset, chipsets, service providers), one must assume that their innovations cover the entire relevant technological spectrum; consequently, the IPC class dispersion of the 152 patent families is

assessed. As this leads to several IPC classes which have a very low number of hits, the third step excludes all classes below 1.0 %, leading to 26 IPC classes covering more than 70% of all inventions. In the fourth and last step, these 26 classes are combined with all 34 companies which have submitted a "Letter of Assurance" to the IEEE until August 1, 2007, and a search is conducted on all patent families, including patent applications. The result is shown in Figure 2 below.

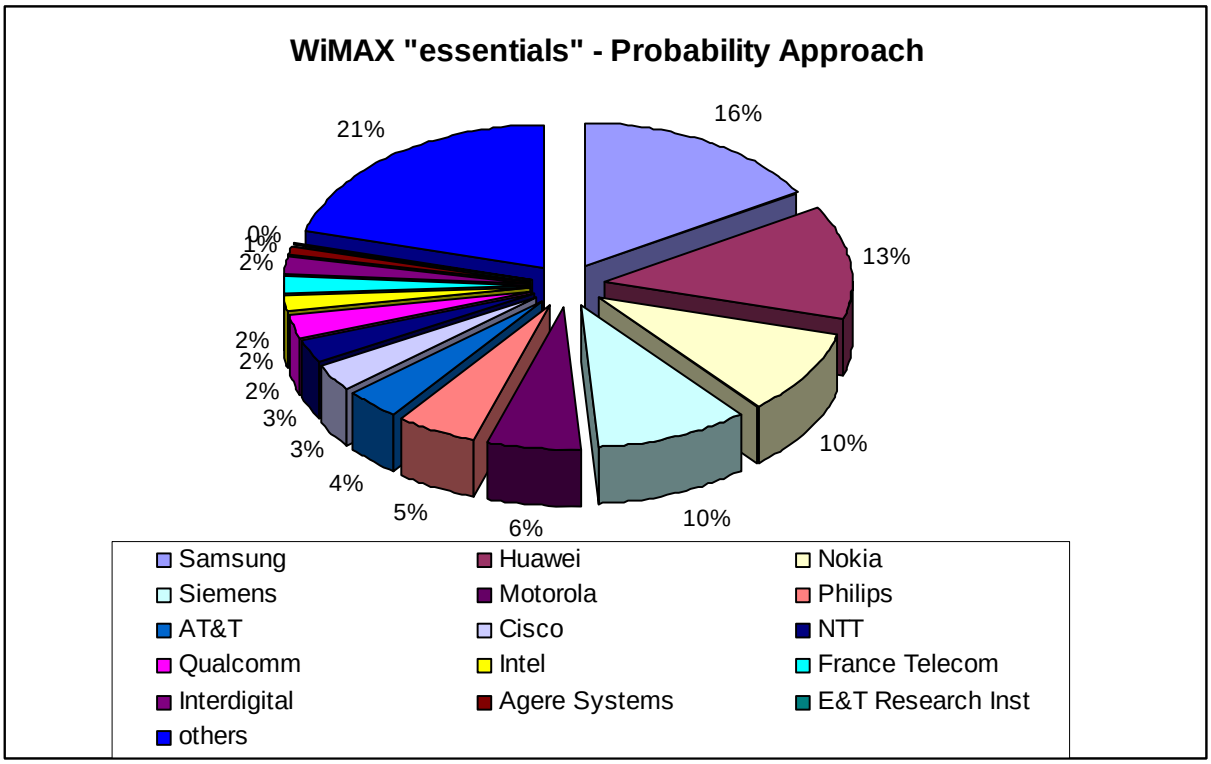

Figure 2: Who "owns" WiMAX? Results of the probability approach

Fragmentation is directly connected to transaction costs – the higher the former, the higher the latter. Even though this result is based on a different approach from the comparable GSM and WCDMA evaluations whose results have been cited above, and the "Probability Approach" suffers various limitations, 4G WiMAX shows significantly higher fragmentation than former standards. GSM in 1998, as argued by ITSUG, showed high fragmentation since at least 17 companies have declared owning essential patents, however, as, GSM (in the meantime) is dominated by three companies. With regard to 3G WCDMA and CDMA-2000, Goodman and Myers found that "four companies own the rights to three quarters of the patents"[46]; similarly Geradin et al. did not ascertain much fragmentation either[47]. The findings here are in line with several arguments[48], most importantly that WiMAX possesses a "vendor-neutral IPR regime", and therefore not suffering from IPR "burdens" and being "very buyer-friendly".[49] Contrary to the advertised conclusions drawn by the "champions of WiMAX", the evidence provided in sections two and three suggests that high fragmentation is followed by an increase in transaction costs,

thereby pushing royalty stacking, and, moreover, hampering competition in the market by creating high barriers to entry.

To evaluate the **business models'** impacts on 4G WiMAX, the companies' primary field of business is examined. Table 2 depicts the result for 4G WiMAX.

Type	Number of Companies ("Top 15")	IPR share
Upstream	5 QUALCOMM, INTERDIGITAL, ETRI, INTEL, AGERE[50]	7,5%
Vertically integrated	7 SAMSUNG, HUAWEI, NOKIA, SIEMENS, MOTOROLA, PHILIPS, CISCO	63,3%
"Outsider" / Manufacturer	0 (per definition)	0%
Buyer / Service Provider	3 AT&T, NTT DOCOMO, FRANCE TELECOM	8,5%
Not defined	---	20,7%

Table 2: WiMAX IPR dominating companies split up according to their business models

Table 2 shows a significant influence of upstream companies with regard to the number of companies involved (5 out of 15), however, the IPR share is clearly dominated by vertically integrated companies. Presumably, the methodology shows too low a share for mobile communication focused upstream companies compared to the widespread operating vertically-integrated companies, still, it is unlikely that the latter group has not understood to bring their IPRs "adequately" into the standard's definition and that they do not dominate the present WiMAX version. Like the evaluation of fragmentation, the analysis of the business models' impacts is based on the number of patents owned by the participating companies – a method whose significance has been criticized: For example, Martin and De Meyer pointed out that "simple patent counting [is] (…) a poor predictor of patent valuation"[51] and the CSFB report adds that "actual implications (…) on the operating of fundamentals of a company"[52] are the result of many other parameters beyond sheer numbers of patents. Nevertheless, the decisive question amounts to whether royalty stacking is favored or weakened in this scenario: As shown by GSM, vertically-integrated companies tend to create a "network of patent cross-licenses", thereby lowering costs within the "royalty club" but hampering the entrance of outsiders.[53] The absence of share-dominating upstream companies might lead to a situation which facilitates the exclusion of their IPRs in future versions of the standard.[54] However, as comparing WCDMA with CDMA-2000 shows, lower shares will not automatically be followed by lower royalty fees since companies license their portfolios, not single patents, and as long as there is nothing more precise than "(F)RAND", nobody can force them to charge a different

price for one patent than for one hundred patents. Thus, companies seeking to implement WiMAX are likely to suffer from the existence of many licenses due to high fragmentation and from high-priced single agreements because of the presence of upstream companies.

7. Conclusion

This paper provides a four-factor framework to evaluate the role of IP in broadband mobile telecommunications. This framework is used to analyze 4G WiMAX, thereby introducing the "probability approach" to obtain an objective result on the fragmentation of essential patents. Supporters of WiMAX argue for a "very buyer-friendly and vendor-neutral IPR regime"[55], as it is based on new radio access technology and no company could leverage an existing dominating IPR position into WiMAX. By contrast, the study shows that WiMAX is plagued by a "thorny thicket": First, high fragmentation increases the impact of royalty stacking due to transaction costs. Second, the IPRs share domination of vertically integrated companies creates barriers to entry and weakens competitiveness. Third, the influence of upstream companies makes reduced royalty costs unlikely. These negative effects cannot be compensated for by the presently still smaller number of essential patents compared to 3G, neither do the upstream companies possess enough share to make the market more open. Here, it would be of special interest to analyze the situation for the competing technologies, LTE and UMB. Consequently, to have Mobile WiMAX successfully deployed in the future as a 4G broadband mobile technology, it will require well-balanced licensing policies of all players involved as well as prospective conduct of courts and antitrust authorities.

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[11] More information on this painful process can be found in **Iversen, Eric J. (1999):** Standardization and Intellectual Property Rights: ETSI's controversial search for new IPR-procedures, available at http://nets.rwth-aachen.de/~jakobs/siit99/proceedings/Iversen.doc

[12] **ITSUG (1998):** "The GSM Standards, IPR and Licensing (An Example of the Restrictive Effects of Standardization)", complaint letter of the International Telecommunications Standards User Group (ITSUG) to the EC, December 1998, available at http://www.tdc.co.uk/datasite/wireless/gsm/_data/IPR%20White%20Paper.pdf

[13] The real cumulative royalty rate for GSM is far from clear. Exemplary mentioned here: **ITSUG (1998)**, pp. 4-5, making out different product groups and best and worst cases, leading to numbers between 3.0% (mobile transceiver, best case) and 30.0% (infrastructure equipment, worst case), and estimating royalty rates for "first handsets" as much as 35% to 40%; **Lemley; Shapiro (2006):** Patent Holdup and Royalty Stacking, in: Texas Law Review, Volume 85, 2007, available at http://faculty.haas.berkeley.edu/shapiro/stacking.pdf, p.2027 citing Thelander arguing between 15-20%; CSFB (2005): **CSFB (2005)**, p.37 and **Goldstein; Kearsey (2004)**, p. 44 both relying on ITSUG (1998).

[14] **Bekkers et. al. (2002)**, p. 186

[15] **Fairfield Resources International Inc. (2007b):** Analysis of Patents Declared as Essential to GSM as of June 6, 2007, available at http://www.frlicense.com/GSM_7-5-2007.pdf

[16] **Goldstein; Kearsey (2004),** p. 51

[17] **Goldstein; Kearsey (2004),** pp. 66-79

[18] **Goldstein; Kearsey (2004),** pp. 170-172. Detailed conditions available at www.3glicensing.com

[19] **Goodman; Myers (2005):** 3G Cellular Standards and Patents, in: Wireless Networks, Communications and Mobile Computing, 2005 International Conference on, Vol.1, 2005, pp. 415- 420, also available at http://www.frlicense.com/wirelesscom2005.pdf; later revised, updated and published as

Fairfield Resources International Inc. (2007a): Analysis of Patents Declared as Essential to WCDMA as of December 31, 2005, available at http://www.frlicense.com/070702wcdmawebreprot.pdf

To explain the historical context, the cited findings and numbers are – if not explicitly marked – taken out of their original publication. The report was sponsored by NOKIA, but the sponsorship was not disclosed at the time of publishing.

[20] The later revised and updated version states that out of 1516 patents 363 are judged essential, i.e. almost 24%; see Fairfield Resources International Inc. (2007a); the yet unpublished version lists 1498 patent families.

[21] **Martin, Donald L.; De Meyer, Carl (2006):** Patent Counting, a Misleading Index of Patent Value: A Critique of Goodman & Myers and its Uses, available at http://ssrn.com/abstract=949439 (pp.16; 25)

[22] **CSFB (2005):** 3G economics: IPR – extending competitive advantage, accessible via http://www.csfb.com/ir/ or email at equity.research@csfb.com (p. 5)

[23] **Geradin, Damien; Layne-Farrar, Anne; Padilla, Jorge A. (2007):** Royalty Stacking in High Tech Industries: Testing the Theory, available at http://ssrn.com/abstract=949599 (pp. 40;7;38). They define the essential 3G patents by merging the declared patents of various ETSI 3G projects. The citations only include citations of the US patent applications with the patent families. However, the question remains whether prior art citations are the best proxy to measure fragmentation. Backward citations have certainly more information value in analyzing the companies reaction as done by Ziedonis than in judging a standard's present fragmentation.

[24] **Kim, Young K.; Prasad, Ramjee (2005):** 4G Roadmap and Emerging Communication Technologies, Boston et al. (Artech House), 2005 (p. 12)

[25] **Etoh, Minoru (2005):** Next Generation Mobile Systems 3G and Beyond, Chichester (John Wiley & Sons), 2005 (pp.12-14); **Kim; Prasad (2005)**, pp. 12-13

[26] Based on **Kim; Prasad (2005)**, p. 56 and **Etoh (2005)**, p. 14

[27] The omen for WiMAX for becoming part of the 4G framework has received additional boost by the suggestion to integrate a specific WiMAX implementation, referred as "OFDMA TDD WMAN", into the existing IMT-2000 family; see e.g. **Unstrung (2007)**: WiMax Gets ITU Standards Boost, available at http://www.unstrung.com/document.asp?doc_id=125477

[28] Several promising collaborations between companies have been concluded, e.g. Sprint and Intel in 2005 (see http://www.intel.com/pressroom/archive/releases/20050505comp.htm), but also between SDOs, e.g. ETSI/IEEE cooperation (for more information see **Friedrichs, Bernd (2007):** BRAN Summary, available at http://portal.etsi.org/bran/summary.asp)

[29] **Geradin et al. (2007)**, p. 7. To bring this framework closer to reality, it would be worth including (5) external influences like the evolutionary aspects of mobile telecommunications and (6) the legal environment. The former is likely to dictate technological progress, the latter gives chances and limits to the companies' conducts. Both factors are included in the original thesis and for a brief discussion it should be referred thereon.

[30] For example, there are little differences in the definition of "essential patents", but resulting in a huge difference. Also, most of the time a single patent would be "reasonable" substitutable, but a company's patent fence ("patent portfolio") in a certain technology is not reasonable replaceable.

[31] **Lichtman, Douglas G. (2006):** Patent Holdouts and the Standard-Setting Process University Chicago Law and Economics, Olin Working Paper No. 292, 2006, available at http://ssrn.com/abstract=902646

[32] The open source software industry might be the best example therefore.

[33] The existing 3G WCDMA patent platform might be an example for that issue. First, most of the companies involved have a rather low degree of essential IPR share, and second, the platform members are increasing over time.

[34] The ideal analysis would be some combination of both, prior art citations (as dependencies) and present fragmentation, however, the author is unaware of any efficient method.

[35] Type and interests to a main extent based on **Geradin; Rato (2006)**, pp. 5-6

[36] Of course, technology has a certain degree of (non-)substitutability independent of some SSOs' definitions of "essential". However, the analysis takes as starting point list of declared essentials from SSOs, that is why this factor is connected to the definitions.

[37] For the listing of difficulties, see e.g. **Goodman; Myers (2005)**

[38] Information based on **Syputa, Robert (2007):** WiMAX/LTE 4G Intellectual Property Rights (IPR) Policy & Market Report, Summary and Conclusions accessible via http://www.maravedis-bwa.com/wimax.html and further information obtained from Robert Syputa; email communication on August 25, 2007

[39] It should be noted that there are more and earlier amendments than the discussed "fixed WiMAX" (802.16-2004) and the "mobile WiMAX" (802.16e). Consequently, many patents that may have been essential for an earlier standard may now be "out".

[40] Several highly relevant remarks:

1. The definition of patent family as it is used here corresponds to the Derwent patent family, i.e. the cluster used by the Derwent database, and relies basically on a shared priority date.

2. The 152 patent families also include some single Cisco and AT&T patents, that have not been disclosed yet to IEEE, but to the WiMAX Forum.

3. The search on the Derwent database was done on August 6 and 7, 2007 by using THOMSON DELPHION.

[41] In fact, its direct critique paper admits that: "Declaring a patent as potentially essential is therefore more a matter of notice than a matter of substance." **Martin; De Meyer (2006)**, p. 14

[42] Assuming all unspecified patents of **Fairfield Resources International Inc. (2007a)** belong to members of the 3G WCMDA platform, the platform owns 62 essential patent families. However, as of September 9, 2007, 3G Licensing claims the possession of 188 essential patent families.

[43] See **CSFB (2005)** for estimated figures on 3G

[44] **EPO Annual Report (2006)**, available at http://www.epo.org/about-us/office/annual-reports/2006.html

[45] The situation at the USPTO is not any better. While it appears that the USPTO has speeded up its prosecution time due to a significant increase in stuff, there is the new problem that the quality of the examination is widely and heavily criticized.

[46] **Goodman; Myers (2005)**, p. 4

[47] **Geradin et al. (2007)**, p. 38. They define the essential 3G patents by merging the declared patents of various ETSI 3G projects. The citations only include citations of the US patent applications with the patent families. However, the question also remains whether prior art citations are the best proxy to measure fragmentation.

[48] For example, the compatibility between WiBro and WiMAX favors a strong position of Samsung; the OFDM based nature of WiMAX gives Wi-Fi oriented companies good possibilities (Cisco, Intel).

[49] **Arthur D. Little (2007)**: HSPA and mobile WiMax for Mobile Broadband Wireless Access. An independent report prepared for the GSM Association, available at http://hspa.gsmworld.com/upload/news/files/13062007093909.pdf (p. 38)

[50] In April 2007, Agere merged with LSI, who sold its mobility product business to Infineon in August 2007.

[51] **Martin; De Meyer (2006),** p. 16

[52] **CSFB (2005),** p. 66

[53] **ITSUG (1998),** p. 8

[54] There will always be a next match: The ongoing revisions make any standard very dynamic, and might also lead to a situation – provided that there is ex ante substitutability – where non-confirming players are punished, see e.g. **Geradin; Rato (2007),** p.42

[55] **Arthur D Little (2007)**, p. 37