The Role Of Intellectual Property In Broadband Mobile Telecommunications At The Example Of 4G WiMAX

By Tobias Kaufmann

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, the business models of the involved companies as well as external influences. This framework is applied to analyze the present 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.

1. Introduction

The relationship between complex industries and IPRs has constantly constituted an interesting subject for IP scholars, which has been substantiated by empirical evidence in various fields, such as biotechnology, semiconductors or wireless networks. Recently, the second (2G) and third generation (3G) of mobile telecommunications have provided one of the most controversial areas.

One group of scholars has argued that the high amount of IPRs may result in a "tragedy of anticommons," or at least in the creation of a thorny "patent thicket," which leads to inefficiency and reduced innovation. Thus, to keep the situation in balance, the scholars warn of IPR overprotection. Others reject this scenario, pointing out each patentee's self-interests and the functioning replies of the market which avoids their counterparts' gloomy predictions. This group refers to the key function of the patent system: awarding an exclusive right for investments in R&D.

Both concepts have deeply penetrated 2G and 3G systems. Now, industry has begun to standardize Beyond 3G (B3G) or 4G systems, intended as a "converging" technology, which combines the wireless communication world and the internet world, and enabling completely new services and business models. This paper addresses the question of the role of IP in this new generation of broadband mobile telecommunications, thereby developing an evaluation framework and mapping this framework to analyze one of 4G's expected radio technologies, "mobile WiMAX."

Based on the theoretical, historical and technical background (Chapter 2), this paper establishes an evaluation framework (Chapter 3) encompassing six factors to examine the role of IP in broadband mobile telecommunications:

- Degree of non-substitutable patents
- Number of essential patents
- Fragmentation of ownership of essential patents
- Essential patent owners' business models
- External influences, i.e., evolutionary and converging aspects
- Legal environment, i.e., case law developments

The framework is used to analyze 4G WiMAX (Chapter 4), overcoming some limitations by using a method called the "probability approach" to identify the fragmentation of essential patents, and focusing on U.S. developments to analyze the legal environment. The analysis finds that WiMAX IPRs show share dominance of vertically-integrated companies as well as relevant presence of upstream companies. Further, it is found that increasing case law offers protection for manufacturers against "outsider" holdouts and against non-(F)RAND complying "insiders."

The paper concludes that in particular 4G WiMAX will be plagued by a thorny patent thicket (Chapter 5), suffering from high transaction costs as well as weak competitiveness. However, in general, the U.S. legal framework for IPR protection appears to be well-balanced with regard to new standardized mobile services.

2. IP and Technology on the Way to 4G

2.1 The Role of IPRs 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,[1] and later addressing patents in biomedical research.[2] 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. 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."[3] Applied to biotechnology, the "spiral of overlapping patent claims in the hands of different owners"[4] 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."[5]

Several scholars have subsequently extended Heller's paradigm, most remarkably Shapiro by transferring the concept to standards-dependent industries like telecommunications and introducing the "patent thicket" as a "dense web of overlapping intellectual property rights, [that…] can have the perverse effect of stifling, not encouraging, innovations":[6] 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.[7] Second, he points to the danger of "step[ping] on a land mine."[8] 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.[9]

Lemley and Shapiro have further substantiated this issue by using 3G and Wi-Fi as examples to show the seriousness of "royalty stacking" by examining the number of patents at stake.[10] Even more striking, they present an empirical study of U.S. court decisions on reasonable royalty rates, finding that the average rate for a single patent within a multicomponent product is 10 percent; this corresponds to significant over-reward for the licensee and "does not reflect commercial reality, at least in the telecommunications and computer industries."[11]

■ Tobias Kaufmann, ETH Zürich, IP Manager, Rhode & Schwarz, Munich, Germany
E-mail: tobias.w.kaufmann@gmail.com

To sum up, the vast number of overlapping patent rights in the hands of many different patentees found in telecommunications is inseparably connected with the worldwide agreed nature of patent protection. As posited by the scholars cited infra, IP over-protection runs the risk of acting as innovation's brake, thus, they propose "coherent boundaries of upstream patents,"[12] with antitrust authorities intervening very reluctantly against IP-based cooperation among horizontal rivals,[13] and the denial of "routinely" issued permanent injunctions to non-competing patent holders.[14]

On the other side of the coin, other scholars perceive a different situation where presently functioning private and legal instruments enable IPRs to foster innovation. Supporters of this idea have addressed the pertinent papers of the above-cited "critical" group with counter-arguments discussed in detail below.

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 at both the theoretical and empirical levels," by drawing "faulty analogies."[15] Epstein and Kuhlik suggest that it is in patent owner's interests to recapture the

1. Heller (1998).
2. Heller; Eisenberg (1998).
3. *Id.*, p. 698.
4. *Id.*, p. 698.
5. *Id.*, p. 699.
6. Shapiro (2001), pp. 1-2.
7. See *id*., pp. 4-6.
8. *Id*., p. 8.
9. See *id*., pp. 6-8.
10. See Lemley; Shapiro (2006), pp. 2025-2029.
11. *Id.*, p. 2034.
12. Heller; Eisenberg (1998), p. 701.
13. See Shapiro (2001), p. 28.
14. Shapiro (2006), p. 24.
15. Epstein; Kuhlik (2004), pp. 54-55.

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."[16] Based on both the vast capital sums needed for further R&D, and on past success, they propose that "the gains from innovation exceed any small dislocations from the so-called anticommons."[17]

Similarly, Ziedonis focuses on companies' conduct to avoid being "fenced in."[18] Through an empirical study of the semiconductor industry from 1980-1994, she shows that fragmentation of patent rights, i.e., the number of companies that own complementary patents, is the driving factor for an organization to increase its own patenting activities. She finds that "firms acquire patents more aggressively than otherwise predicted when markets for technological inputs are highly fragmented."[19] According to Ziedonis, this behavior can be traced back to the requirement that a patentee have a stronger market position to effectively obtain cross-licenses.[20] Following her line of argument, the market already offers a successful answer to high fragmentation: increased patent ownership, which generally speaking has a positive effect on innovation and which does not primarily increase royalty stacking effects, but rather fosters cross-licensing.

In 2006, Lichtman provides a different reply to the issue of fragmentation. He suggests that there is a misleading link between the growth of patent numbers and its fragmentation on the one side, and the increase of the risk of anticommons, holdouts and royalty stacking on the other. Lichtman argues that a converse proportionality exists. He suggests that the greater the number of patent holders in a holdout position, the lower their incentive to litigate, as their expected return "will only include only a fractional share of the total holdout value […i.e.,] more patents means less money per patent holder."[21] For companies participating in a standards-driven market, he suggests two strategies: either "stop licensing patent rights entirely […or] engage in licensing strategies modeled after 'most favored nations' clauses."[22] Finally, he concludes that precisely because there are so many patent holders, many resources will come into efficient use.[23]

In a 2006 paper, Geradin and Rato exhaust the conflict of IP standardization and competition law in stating that the "waiver theory," i.e., making a (F)RAND commitment during standardization leads to a renouncement of injunctions, and is "grounded neither on statute nor case-law"[24] Rather, they argue that it would lead to a system "akin to compulsory licensing"[25] since without a claim for injunctions, the patentee has 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."[26]

Finally, in a 2007 article, Sidak offers a direct response to Lemley and Shapiro. He claims that after the Supreme Court's 2004 Trinko decision,[27] "[i]t is unambiguous […] that American antitrust law does not forbid a monopolist to charge as high a price for her product as she likes."[28] Sidak rightfully notes that the legal landscape is different in Europe and therefore requires different portfolio management[29] referring to the Supreme Court's view that "opportunity is critical to preserving competitive incentives for investment in innovation."[30] Consequently, a patentee cannot be over-rewarded; after all, it is his "right to charge as high a price as he likes."[31] He argues that "there is no conclusive evidence that patent holdup and royalty stacking are occurring."[32]

To conclude, this second group argues that the commercial reality is different from the afore-summarized scholars' positions, highlights the first group's faults and lack of evidence,[33] advises against toleration of deliberate infringement,[34] points at the positive effect of high fragmentation,[35] upholds the need for injunctions between non-competitors,[36] and aims for

16. *Id.*, p. 55.

17. *Id.*, p. 58.

18. Ziedonis (2004), p. 804.

19. *Id.*, p. 817.

20. See *id.*, p. 818.

21. Lichtman (2006), p. 3; p. 10.

22. *Id.*, pp. 10-11.

23. See *id.*, pp. 12-13.

24. Geradin; Rato (2006), p. 15.

25. *Id.*, p. 17.

26. *Id.*, pp. 15-17.

27. *Verizon Communications, Inc. v. Law Offices of Curtis V. Trinko*, 540 U.S. 398 (2004).

28. Sidak (2007), p. 3.

29. See *id.*, p. 3.

30. *Id.*, p. 4.

31. *Id.*, p. 6.

32. *Id.*, p. 23.

33. See e.g. Epstein; Kuhlik (2004); Sidak (2007).

34. See Georges (2007); see Epstein (2005).

35. See Lichtman (2006).

36. See Geradin; Rato (2006), p. 17.

capital intensive industries on the one hand, but also smaller and medium-sized players on the other. They offer the question of whether at the end of the day, if patentee's 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?

2.2 Experiences of the Mobile Telecommunication Industry

Such competing concepts have deeply penetrated the patent landscape in mobile telecommunications. This chapter depicts crucial steps of mobile telecommunications' IPRs experiences, in particular with respect to 2G and 3G, and how this shaped the status quo.

During the 1980s, the first generation of mobile communication systems based on analog cellular technology was marketed. Its services were restricted to voice transmission, its phones were expensive to produce and were about the size of a briefcase.[37] In short, IP was not a driving issue.

While this technology was marketed, the second generation, based on digital technology, was developed, passing its first steps towards standardization, before taking off in the 1990s. Different systems based on different technologies evolved. While at the beginning TDMA systems prevailed, e.g., GSM in Europe, there were also CDMA systems evolving, which were implemented in North America under the IS-95 standard. Due to significant improvements in the semiconductor industry, cheaper and smaller ASICs used in the production of mobile phones led to a significant shrinkage of phone size, making the phones portable. In addition, digital technology enabled better speech quality, and popular new services like SMS evolved.[38]

However, with the establishment of GSM in the late 1980s, facilitated by inter-governmental cooperation throughout Europe, the telecommunication industry experienced a "serious clash between IPRs and standardization,"[39] forming the starting point for the "painful history of GSM patent licensing [which] left a lingering resentment within the industry."[40]

When in 1982 the "Groupe Spécial Mobile"[41] was formed, IPRs played such a marginal role that an IPR policy was not even discussed. However, things changed dramatically in 1987 when a "Memorandum of Understanding" was signed. The participating parties became aware that there were a substantial number of patents, which were "essential"[42] to any GSM implementation and MOTOROLA, as the largest holder of essential patents at that time, intentionally refused to provide a "general declaration" (or "license with general declaration strategy").[43]

One of the newly established ETSI's first tasks comprised setting up a binding IPR policy. It took more than five years of debate, to November 1994, to agree on an IPR policy (after a more rigid former version had been abandoned due to competition law complaints, members' formal protests, and intense political pressure from the U.S.A.).[44] The abandoned version, nicknamed "licensing by default system" included an obligation for members to actively search their IPRs, and to notify ETSI within 180 days of any IPR they deemed essential, in addition to an implicit obligation of the IPR holder to license its IPRs on fair, reasonable and non-exclusive terms, unless specific actions were taken. The pendulum swung back to the IPR holders under the 1994 version. Thus, instead of the obligation to search for IPRs, there was a bona fide requirement to disclose identified essential IPR, and a choice whether to license on FRAND terms or to provide a written declaration outlining reasons for the non-willingness to make licenses available.[45]

In 1998, the International Telecommunications Standards User Group (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.[46] In addition, ITSUG added that the "lack of transparency" makes it impossible to ascertain who in the supply chain is responsible for which royalties and to judge whether license terms correspond to

37. See Bi et al. (2001), pp. 110-111.

38. See *id*., pp. 110-111.

39. Bekkers et al. (2002), p. 173

40. Goldstein; Kearsey (2004), p. 43.

41. GSM was originally the abbreviation for this group.

42. In short, a patent is deemed to be "essential" for a standard if this standard cannot be implemented without infringing that patent. A more detailed discussion is provided in chapter 4.

43. *Id.*, p. 177.

44. See Iversen (1999), p. 1.

45. See *id.*, pp. 6-8; also Bekkers et al. (2002), pp. 180-181.

46. ITSUG (1998), pp. 4-6; see also Goldstein; Kearsey (2004), pp. 43-45.

FRAND conditions.[47] This is evident in the figures showing a range from 3 percent to 40 percent of the ex-works selling price,[48] compared to the "telecommunications industry norm of about 5 percent."[49] Additionally, from a SME's perspective, the ITSUG alleged the existence of "a low/zero club for established European telecommunications players"[50] due to the effects of cross-licensing agreements between major (vertically-integrated) concerns.

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."[51] Further, in 2007, FAIRFIELD RESOURCES INTERNATIONAL presented additional evidence for the lack of transparency by finding that only about 25 percent of the declared essential patent families were actually judged essential.[52]

In the middle of the 2G period, data and multimedia services appeared, leading from the original pure circuit-switched networks to packet-switched ones. These standards became known as 2.5G (e.g., GPRS). Major advances, like improved resistance to interference and increased bandwidth,[53] allowed a highly IP aware and originally CDMA based competitor, QUALCOMM, to enter the TDMA rooted communication market, who will claim later that these standards have adopted innovations as they were originally developed and patented by QUALCOMM for CDMA based systems.[54] Since TDMA systems are more widely dispersed within the 2G and 2.5G standards, these "adaptations" set the basis for QUALCOMM's IPR income generation.[55]

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.[56] After long discussions with the antitrust authorities, in particular the U.S. Department of Justice (DOJ), the "3G Patent Platform Partnership" finally received approval to set up common patent licensing organizations. However, the DOJ demanded that each individual 3G technology must be governed by an independent Platform Company, explicitly referring to potential inter-technology competition that would be eliminated if designed like originally planned as one organization across all five 3G interfaces.[57]

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 percent of the net sales value.[58]

At the 2005 IEEE WirelessCom, Goodman and Myers presented their evaluation of 3G relevant patents.[59] 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,[60] 3GPP (WCDMA) as well as 3GPP2 (CDMA2000),

47. See *id.*, p. 5.

48. 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), p. 2027 citing Thelander arguing between 15-20%; CSFB (2005), p. 37 and Goldstein; Kearsey (2004), p. 44 both relying on ITSUG (1998).

49. ITSUG (1998), p. 6.

50. *Id.*, p. 8.

51. Bekkers et. al. (2002), p. 186.

52. Fairfield Resources International Inc. (2007b).

53. See e.g. Mobiledia (2005).

54. See *Id.*

55. In 2006, QUALCOMM generated 2.75 billion U.S.-$ in licensing fees, more than one third of its total revenues, or, almost 80% more than the company's complete R&D budget of 1.54 billion U.S.-$. See Qualcomm Annual Report 2006 (2006).

56. See *Id.*, pp. 66-79 and ETSI (1999).

57. "Approval" means the issuance of a "Business Review Letter," see DOJ Business Review Letter for 3G, printed in Goldstein; Kearsey (2004), pp. 466-485. A detailed discussion of the antitrust authorities' letters (EC, DOJ, JFTC) can be found in Goldstein; Kearsey (2004), pp. 178-225.

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

59. See Goodman; Myers (2005); later revised, updated and published as Fairfield Resources International Inc. (2007a). 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.

60. *Id.*, p. 5.

"nearly 80 percent 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.[61] 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."[62] 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.[63]

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."[64] 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?"[65]

To evaluate the impacts of the 3G patent thickets, in particular in comparison with the 2G GSM issues, this paper offers certain improvements: While the total cumulative royalty rate for 3G equipment seems to resemble the 2G quiz game, the figures of the worst-case scenarios have declined. In 2005, 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 percent for those vendors without an IPR position to trade off,"[66] but also referred to "concerns that the rates could be as high as 25-30 percent."[67] The trade off factor might constitute such an important role that CSFB estimates NOKIA's rate, as a very strong IPR holder, around 7 percent "at the very most," while weaker competitors might face a royalty rate of about 20 percent, leading to a substantial disparity in manufacturing costs. The total IPR licensing market "could be as large as $8.1bn by 2010."[68]

"[N]o evidence of a significant royalty stacking in the 3G telecoms industry"[69] is found by Geradin et al. in 2007. They rely on a model which puts the market value of publicly traded companies into relation with the fragmentation of patent rights. As they do not find a statistically significantly negative impact on vertically integrated companies, they reject the claim that royalty stacking exists within 3G.[70] Moreover, 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.[71] According to their report, 86 percent of all essential patents' prior art listings are held by four companies. Consequently, they state that the requirement of high fragmentation is unmet.[72]

A strong factor in favor of a competitive market and against insuperable barriers to entry into the mobile telecommunication market can be inferred from APPLE's late but successful release of its IPHONE. While not owning "essential" IPRs, APPLE endowed—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 before.

Finally, the fact that competition law also works for keeping a well-balanced situation was recently shown by the U.S. Court of Appeals for the Third Circuit in 2007, deciding in *Broadcom v. Qualcomm*[73] a UMTS/WCDMA dispute on the consequences of non-compliance with ETSI's FRAND terms. The court, referring to *Rambus*,[74] set out that under four

61. 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.

62. Goodman; Myers (2005), p. 5.

63. See *Id.*, pp. 4-5.

64. Martin; De Meyer (2006), p. 16.

65. *Id.*, p. 25.

66. CSFB (2005), p. 5.

67. *Id.*, p. 6.

68. *Id.*, p. 6.

69. Geradin et al. (2007), p. 40.

70. See *Id.*, pp. 6-7; pp. 28-32.

71. See *Id.*, p.7.

72. See *Id.*, 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 U.S. 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. Also discussed briefly in chapter 3.

73. *Broadcom v. Qualcomm*, No. 06-4292 (3d Cir. Sept. 4, 2007).

74. In the Matter of Rambus, Inc., No. 9302 (F.T.C. August 2, 2006).

conditions, non-compliance with (F)RAND "is actionable anticompetitive conduct."[75] While it is now up to the district court to establish any deeper meaning of (F)RAND, the judgment has transferred general principles into the tangible context of telecommunications standard setting organizations (SSOs). Similar antitrust complaints are pending before the European Commission, alleging QUALCOMM's refusal to license essential patents on FRAND terms, and further charging excessively high royalty rates on WCDMA.[76]

2.3 The 4G WiMAX Environment

With this apparently irreconcilable clash of interests between upstream, royalty-dependent companies on the one side, and outsiders and vertically-integrated companies seeking lowest production costs on the other, mobile communication is just starting into 4G. As mentioned, 4G's major challenge is to remove "the gap between the wireless and Internet worlds, […combining] the positive aspects of the two worlds,"[77] thereby leading to new set of converging services and applications.

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."[78] 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.

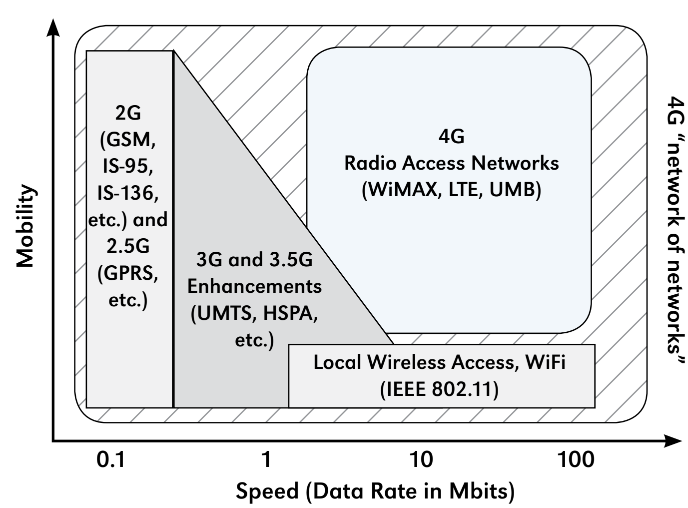
Figure 1 provides an overview of 4G's role: It should not be understood as a specific standard, or a set of competing standards, rather it provides a "network of networks," including at its core new radio access networks like "WiMAX." However, 4G refers to a heterogeneous rather than a homogeneous network, being built out of a fusion of existing and newly developed elements.[79]

The International Telecommunication Union (ITU) intends to define 4G within its IMT-Advanced process by 2009, expecting the deployment starting commercially in 2011.[81] It is expected that several air interfaces will become part of the 4G definition, besides WiMAX,[82] in particular LTE (3GPP's WCDMA successor) and 3GPP2's successor UMB, as both underlying technologies are already part of the IMT-2000 framework.[83]

While in the subsequent chapter this paper establishes a general evaluation framework for broadband mobile telecommunications, the empirical analysis in Chapter 4 is restricted solely to WiMAX as 4G's radio solution. Several indicators suggest WiMAX being successfully deployed in future.[84]

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,

Figure 1: Radio Access Networks And The Role Of 4G[80]



75. *Broadcom v. Qualcomm*, p. 24: (1) consensus-oriented private standard-setting environment, (2) a patent holder's intentionally false promise to license essential proprietary technology on FRAND terms, (3) coupled with an SDO's reliance on that promise, (4) the patent holder's subsequent breach of that promise.

76. See EDN (2005).

77. Etoh (2005), p. 16.

78. Kim; Prasad (2005), p. 12.

79. See Etho (2004), p.12-14; Kim; Prasad (2005), pp. 12-13.

80. Based on Kim; Prasad (2005), p. 56 and Etoh (2005), p. 14.

81. See Unstrung (2007b).

82. 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 Unstrung (2007b).

83. See Unstrung (2007a); Unstrung (2007b).

84. For example, Intel/LG agreement, see InfoWorld (2004); ETSI/IEEE cooperation, see Friedrichs (2007).

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.

3. Construction of the Evaluation Framework

With the afore-mentioned theoretical, historical and technical background in mind, this chapter constructs the 4G patent evaluation framework. The framework builds the basis for analyzing 4G WiMAX with regard to 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.

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. Nevertheless, there may be cases without ex ante substitutability, e.g., due to broad basis inventions, or a substitute may be available for a company's single patent, but not for a company's patent fence in a certain technology.[85] However, if a standard is passed—as will be the case for "Mobile WiMAX"—the ex ante situation is irrelevant. The question then shifts to the substitutability within the "essentials" and the definition of "essential."

The second critical factor consists in the number of patents. There are two lines of arguments to dispute the fateful relationship between a high number of patents and high transaction costs: First, reality seems to have produced some counter-evidence, by complex standards with hundreds of patents leading to low royalty rates that might be as low as zero, e.g., BLUETOOTH.[86] However, in these cases, the result of the low cost of IPR licensing depends more on the business models of the involved companies: while vertically integrated companies might generate profit through cheap production and high cost sales, R&D-only companies (or upstream companies) can only give away patents for free if they can profit in another way after successful implementation, e.g., in the product-related service market.[87] Second, as shown above, Lichtman presented the theoretical counter-argument that a high number of patents accompanied with a high share of fragmentation is beneficial for reducing the risk of holdouts and high royalties. Primarily, Lichtman's argument is more dependent on fragmentation rather than on sheer numbers; furthermore, he ignores some dynamics, i.e., that only if all participants follow non-royalty based business models can the scheme work.[88] 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,[89] 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 by a company's reaction of increased self-patenting has the potential result of high fragmentation. 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

85. The best example may be found in 3G development. If 3GPP had been able to avoid QUALCOMM's CDMA patent fence, why would they have issued standards which are at least to a substantial part based on QUALCOMM' s patents? Argumentation partly based on Geradin; Rato (2006), p. 22.

86. A sophisticated study on various patent pools including the BLUETOOTH pool can be found in Layne-Farrar and Lerner (2006); for royalty free BLUETOOTH see pp. 11-12.

87. The business models around open source software are a notorious example for that issue.

88. Once again—open source software industry.

89. 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.

costs, as can be seen for GSM.[90]

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.

The fifth factor deals with external influences. This factor, split in two parts, is vital for all broadband mobile communication, especially in the case of highly converging technologies such as 4G. First, is the evolutionary aspect, as shown by the "evolving" development of 3G encompassing the need for backwards compatibility. Interestingly, 3G air interfaces evolved from 2G systems (TDMA/CDMA), while WiMAX is based on new technology (OFDMA). The following analysis will focus on how this new "4G independence" influences traditional fields of innovation. Second, there is the converging aspect which evolves as 4G intends to open far-reaching new fields of services for consumers and new businesses for companies. The pertinent question thus refers to the companies' conduct with regard to R&D, e.g., by joint ventures, by acquisition, or by a company's own R&D rearrangements, and how this influences IPR in broadband mobile communications in general. Since this factor opens a widespread economical field, the following analysis is restricted to providing exemplary indications and analyzing their influence.

Table 1: Dominating IP Based Interests Of Major Business Models

Type[91]	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

The sixth and final factor is the legal environment. Being the cornerstone of all IPR analyses, its unpredictable changes may make complete portfolios worthless or unenforceable; it may also open completely new fields of relevant patentability. While the destiny of any broadband technology might be influenced by a variety of decisions, the following analysis focuses on the most crucial, standard-related judgments.

The results of the above factors 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.

4. Analysis of 4G WiMAX

As discussed, complementary and non-substitutable patents must ex post be regarded with the definition of "essential" patents:[92] Using the most narrow definition of "essential," as it is (almost) used by ETSI,[93] leads to a list (or an assumed pool) of "essentials" consisting solely of complementary patents, none can be substituted; whereas, the IEEE's present IPR policy, which is relevant for WiMAX, provides a broader definition: The IEEE's definition encompasses "either mandatory or *optional portions*," and permits a patent to be deemed essential if the use of non-infringing alternatives is not feasible due to "*commercial[] and technical[]*"[94]

90. 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.

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

92. 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.

93. See ETSI IPR Policy (2006) 15: "ESSENTIAL (...) means that it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art (...) to make (...) EQUIPMENT or METHODS which comply with a STANDARD without infringing that IPR. For the avoidance of doubt in exceptional cases where a STANDARD can only be implemented by technical solutions, all of which are infringements of IPRs, all such IPRs shall be considered ESSENTIAL."

94. See IEEE-SA Patent Policy (2007) 6.1, emphases added.

reasons. Obviously, comparing a 4G WiMAX declared "essential" list to a (ETSI based) WCDMA list, the factor cannot be underlined with a concrete number. Still, the declarations made to the IEEE provide for a higher degree of substitutability, thus the resulting WiMAX IPR picture is ultimately less thorny than the same analysis of 3G WCDMA essentials.

While it has always been difficult to establish a complete list of declared essential patents for one specific standard,[95] 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.[96] Syputa, a frequently quoted analyst from a broadband wireless research institute, posits that there are 550 essential (single) patents for WiMAX[97] and—in total—320 judged essential patent families for WiMAX, LTE and UMB.[98] 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.[99] These single patents result in 152 patent (and application) families.[100] 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 valuable criticized points.[101] On the basis of their three analyses,[102] they detect values for the ratio of declared to evaluated essentials of approximately 25 percent. 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.[103]

The question with respect to the number of essential patents cannot be answered statistically with a concrete number, but rather with three important conclusions: First, the initial version of mobile WiMAX shows significantly less patents declared essential than later versions of GSM and WCDMA, whereby the number is likely to increase over time. Second, due to differing definitions of "essential," there are indicators suggesting that the ratio of judged essentials among the lists of declared essentials is higher, whereby this factor is compensated through the disposability of some degree of substitutability. And third, 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 dollar turnovers per year on which companies heavily rely.[104] 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

95. For the listing of difficulties, see e.g. Goodman; Myers (2005).

96. This issue will be dealt with in more detail when discussing the sixth factor.

97. See Syputa (2007), p. 12.

98. Information obtained from Robert Syputa; email communication on August 25, 2007.

99. 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."

100. 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 Delphion.

101. 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." Marin; De Meyer (2006), p. 14.

102. Goodman; Myers (2005); Fairfield Resources International Inc. (2007a); Fairfield Resources International Inc. (2007b): Ratios: GSM 27%, W-CDMA 24% and CDMA-2000 20.5%.

103. 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.

104. See CSFB (2005) for estimated figures on 3G.

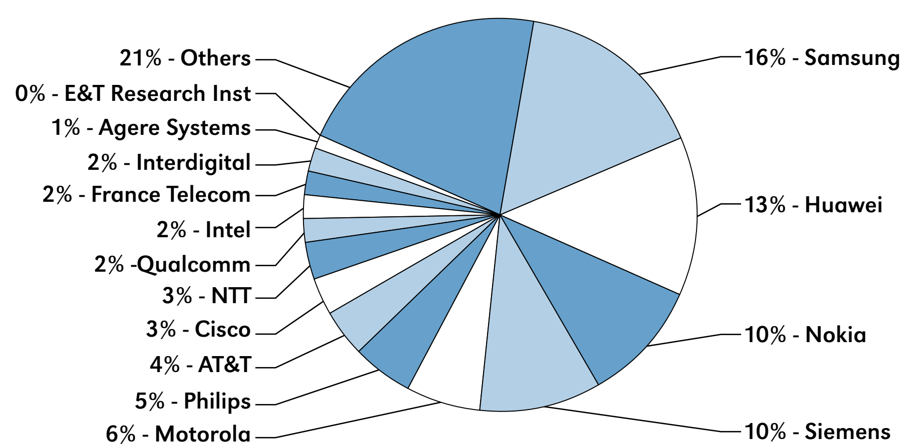
the most expensive group.

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 analyzing methods. Moreover, long time periods from filing to grant hamper precise analyses 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,[105] plus 12 months priority for many patents, i.e. most patents granted in 2006 were for inventions made in 2001.[106]

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 class dispersion of this 152 patent families is assessed making use of the international patent classification (IPC).[107] As this leads to several IPC classes which have a very low number of hits, the third step excludes all classes below 1.0 percent, leading to 26 IPC classes covering more than 70 percent 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.

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 than the comparable GSM and WCDMA evaluations referred to in chapter 2.2, and the "Probability Approach" suffers various limitations, discussed in the appendix, 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, GSM (in the meantime) is dominated by three companies.[108] With regard to 3G WCDMA and CDMA-2000, Goodman and Myers found that "four companies own the rights to three quarters of the patents";[109] similarly Geradin et al. did not ascertain much fragmentation

Figure 2: Who "Owns" WiMAX? Results Of The Probability Approach



105. See EPO Annual Report (2006).

106. The situation at the USPTO is not any better. Although there seem to be some recent improvements due to a significant increase in stuff, the problems of the last years remain unsolved: For example, the U.S. application databaase lists for the "FDMA" IPC class H04J 1/00 2.166 filed applications since priority year 2001, whereas only 378 thereof have been granted (17.5%).

107. It is relied on Derwent's automatically updated IPC-R field, i.e. the ongoing 3-months IPC updates (in effect since January 1, 2006) do not affect the IPC analysis as former patents are reclassified in cases of change of IPC classes.

108. For detailed GSM fragmentation figures, see Fairfield Resources International Inc. (2007b).

109. Goodman; Myers (2005), p. 4.

either.[110] The findings here are in line with several arguments,[111] most importantly that WiMAX possesses a "vendor-neutral IPR regime," and therefore not suffering from IPR "burdens" and being "very buyer-friendly."[112] Contrary to the advertised conclusions drawn by the "champions of WiMAX,"[113] the evidence provided in chapters 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.

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.

Table 2: WiMAX IPR Dominating Companies Split Up Acording To Their Business Models

Type	Number of Companies ("Top 15")	IPR Share
Upstream	5: Qualcomm, Interdigital, ETRI, Intel, Agere[114]	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%

Like the evaluation of the 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"[115] and the CSFB report adds that "actual implications (…) on the operating of fundamentals of a company"[116] 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.[117] 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.[118] 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.

110. See 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 U.S. patent applications with the patent families. However, the question also remains whether prior art citations are the best proxy to measure fragmentation.

111. 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).

112. Arthur D. Little (2007), p. 38.

113. *Id.*, p. 38.

114. In April 2007, Agere merged with LSI, who sold its mobility product business to Infineon in August 2007, see LSI Press Release (2007).

115. Martin; De Meyer (2006), p. 16.

116. CSFB (2005), p. 66.

117. ITSUG (1998), p. 8.

118. 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. Gearadin; Rato (2007), p.42.

To establish the influence of the fifth factor—**external influences**—some exemplary deeper patent analyses were made, in particular from NOKIA (as a vertically-integrated company) and QUALCOMM (upstream). To show industry trends, a time grid was established splitting developments since 1987 into three periods, a "modern 2G period" (1987-1996), a "3G period" (1997-2002) and a "4G period" (2003-2005).[119] Both portfolios show robust evolutionary aspects in the first place, and relevant new converging influences coming second.

Throughout the analyzed 3G and 4G periods, about one third of NOKIA's patent filing took place within four IPC groups (the IPC main group and its subclasses).[120] Similarly, four IPC groups rank among QUALCOMM's "Top 5" in all three examined periods. For both companies, these groups cover the "traditional" mobile communication fields.[121] Besides these constants, the evolutionary analysis also shows a logical trend: While NOKIA originally filed many patent applications in the TDMA based IPC classes and QUALCOMM's filings were grouped into the CDMA classes, both classes show constantly declining numbers. In contrast, frequency-division and orthogonal multiplex systems became more important for both companies, being in line with the OFDMA based WiMAX technology. However, the portfolios analyzed show also substantial converging influence: For NOKIA, digital computing and data processing, e.g., inter-processor communication, text processing or information retrieval meanwhile provide two of the top 10 IPC groups for applications—after having been of no significance in the 2G period and only modest importance in the 3G area. Obviously, this mirrors the influence of broader and more complex devices enabling new services and applications. QUALCOMM's portfolios reflect the recognized growing importance of audio and video multimedia in mobile communication systems, i.e. two IPC classes related to television systems showed constant increase and now rank on sixth and eighth positions among QUALCOMM's patent filings.[122]

In general, companies focus their R&D investments on their core businesses. If vital new fields arise within a portfolio, these technologies can be regarded as being located at a company's "heart of business."[123] Even though NOKIA and QUALCOMM are traditional mobile communication companies, they have understood that their technological R&D core business has become broader than the specification of radio interfaces or networks. This trend will increasingly create space for new innovators, but, as shown in both portfolios, the wireless communication techniques will remain the dominating part within the core of the broadband mobile communication industry.

Finally, this paper will analyze the **legal environment** of 4G WiMAX, with regard to influential **case law developments**. Decisions reducing the risk of hold-outs are gratifying from an economics perspective. As Shapiro has shown, high royalty rates are often the result of negotiations under the threat of injunctions. After the Supreme Court's Ebay decision, a successful claim for a permanent injunction based on the four-factor test has become highly dependent on the status of the parties in the market: If the parties were competitors, injunctions would be granted; if they were not, injunctions were routinely denied.[124] However, a U.S. district court recently granted a permanent injunction for an Australian governmental research organization against a U.S. company, even though the parties were not in a directly competing relationship, issuing a particularly narrow decision that might be "too narrow to be useful for patent holding companies."[125] Obviously, this makes WiMAX less susceptible against a "tragedy of anticommons" by providing a shield against hold-outs; however, if eBay's reasoning does not permit application for injunctions in lawsuits between upstream and vertically-integrated companies, Epstein's predicted toleration of deliberate infringement might find its way into broadband mobile telecommunications.

While eBay appears for now to offer (at least in the U.S.A.) a functioning shield against non-compet-

119. The years mentioned refer to the priority years of the inventions. Due to the 18 months disclosure shift, the analyzes is "dated back" by one and a half years.

120. For a general introduction into the IPC classification scheme, see WIPO IPC Guide (2006). For example, H04Q builds a "subclass," H04Q 7/00 is a "main group" and H04Q 7/06 a "subgroup." For the research done in this report, all subclasses are grouped under the main group, and it is referred to as "IPC group," e.g. H04Q 7/00 including all its subclasses.

121. Inter alia, selecting arrangements with radio links (H04Q 7/...), data switching networks (H04L 12/..) and various aspects of transmission systems (H04B 7/.., H04B 1/.., H04L 29/..).

122. In fact, QUALCOMM has an own business unit dealing with mobile multimedia.

123. Kelly (2001) citing an unnamed "head of IP at a major high-tech concern."

124. See Georges (2007); Jackson; Nugent (2007).

125. Jackson; Nugent (2007).

ing, outsider holdouts, there is increasing case law prohibiting SSO participating companies which do not comply with the SSO's (F)RAND and disclosure provisions from enforcing their patents and facing liability under antitrust statutes. As previously discussed, *Broadcom v. Qualcomm* makes it unambiguously clear that (F)RAND terms—whatever it means—are enforceable under antitrust law and, for broadband mobile technologies, thereby a second shield is generated, against "insiders."

5. Conclusion

This paper provides a framework encompassing six factors 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,"[126] 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, as well as whether WiMAX fragmentation—in case of its commercial success—pushes additionally Ziedonis' "race for patents."

The analysis of evolutionary and converging technological influences demonstrates that new technologies have reached the mobile communication companies' "heart of business."[127] Compared to the slow spreading of 3G services with the companies' rather narrow approach, this development seems to be a more promising track for converging technologies.

Finally, the study also suggests that the U.S. IP and antitrust legal framework for IPR protection is positioned well-balanced with regard to the standardized development of broadband mobile services. More protection, as shown at the example of injunctions, may create a serious burden on innovation due to the susceptibility from "outside"; whereas tolerating any breach of (F)RAND terms would jeopardize implementation of standards from "inside."

Nevertheless, there is a very thin line which easily can be crossed: IP and antitrust law aim to foster innovation, thereby providing incentives to explore and further improve unknown and risky technologies, whereby in telecommunications, standardization including (F)RAND is an essential part of that process. If exploitation of IP on (F)RAND terms is "unreasonably" restricted—be it by courts refusing claims for injunctions which fulfill the traditional tests, or competition authorities fixing prices which reduce innovators' incentives—what will be the value of IP in broadband mobile telecommunications? ■

126. Arthur D Little (2007), p. 37.

127. Kelly (2001) citing an unnamed "head of IP at a major high-tech concern."

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Acronyms and Abbreviations			
2G	Second Generation of Mobile Communication Systems	IPC	International Patent Classification
3G	Third Generation of Mobile Communication Systems	IS-95	Interim Standard 95
3GPP	3rd Generation Partnership Project	ITSUG	International Telecommunications Standards User Group
3GPP2	3rd Generation Partnership Project 2	ITU	International Telecommunication Union
4G	Fourth Generation of Mobile Communication Systems	LTE	3GPP Long Term Evolution
ASIC	Application-Specific Integrated Circuit	OFDMA	Orthogonal Frequency Division Multiple Access
B3G	Beyond 3G	RAND	Reasonable and Nondiscriminatory
CDMA	Code Division Multiple Access	RIM	RESEARCH IN MOTION LIMITED
CSFB	CREDIT SUISSE FIRST BOSTON	SDO	Standard Development Organization
DOJ	Department of Justice	SMEs	Small and Medium Enterprises
ETSI	European Telecommunications Standards Institute	SMS	Short Message Service
FDMA	Frequency Division Multiple Access	SSO	Standard Setting Organization
FRAND	Fair, Reasonable and Nondiscriminatory	TDMA	Time Division Multiple Access
GSM	Global System for Mobile Communications, originally: Groupe Spécial Mobile	UMB	Ultra Mobile Broadband (3GPP2)
GPRS	General Packet Radio Service	UMTS	Universal Mobile Telecommunications System
IEEE	Institute of Electrical and Electronics Engineers	USPTO	United States Patent and Trademark Office
IMT-2000	International Mobile Telecommunications-2000	WCDMA	Wideband Code Division Multiple Access
IMT-Advanced	International Mobile Telecommunications-Advanced	WiMAX	Worldwide Interoperability for Microwave Access

Appendix

Discussion of the Most Relevant Restrictions

- No framework is complete

This paper aimed at analyzing the role of IP in broadband mobile telecommunications, thereby developing a framework and using this framework to analyze one specific example. The six factors ascertained have appreciable impact on the shape of future mobile technologies' IPRs; however, there is no framework which reflects the complete environment, since, for example, every company follows different strategies towards IPRs.

- Essentiality of patents cannot be determined on a statistical basis

Compared to some predecessor radio technologies, there is no publicly available list of "declared essentials," and, unfortunately, nobody has yet made publicly available any comparable results. Moreover, there is a striking difference between "declared essentials" and "real essentials," as, e.g., pointed out by Goodman; Myers (2005) and its direct critique paper Martin; De Meyer (2006). Judging essentiality requires weeks or months of work at courts, and cannot be solved on a statistical macro level.

- The "probability approach" provides a first snap-shot on a macro level

The method and its different steps behind the "probability approach" are described in chapter four. Since key words are traditionally a rather weak element in patent searches, this paper makes use of the IPC scheme. No distinction could be made between filed applications and granted patents, nor does the method include any geographical differentiations. However, the result remains convincing in two dimensions: From an academic point of view, the result establishes the starting point for its connected conclusions, from a practical perspective, it gives some guidance for the necessary portfolios to look at for further evaluations.

- The derivation of interests from the business models is a simplification

Of course, every company is different, follows different aims with respect to products and marketing as well as to R&D and IP. The categorization and the derived interests simplify the complex reality of business decisions.

- External influences and the legal framework only cover a small fraction within a large puzzle

In particular the last two factors are highly diverse, each could be worth a bunch of reports. However, like in a large puzzle, not all parts are equally demanding for the puzzle's completion: The absorbed aspects provide the key elements which most likely have most decisive impact on the role of IP in broadband mobile telecommunications.

Acknowledgement

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. I would like to thank Dr. Robert A. Myers for supervising this thesis, for providing passionate effort, valuable information and encouraging comments. I would also like to express my sincerest gratitude to Fritz Teufel for co-supervising the work and providing inspiring guidance. It was a great pleasure and unique honor for me to work with them. Further, my sincere gratitude goes to Dr. Herbert Laederach, the supervisor of the program, for his farsighted management of the program, as well as to Prof. Dr. Gérard Hertig, the program's delegate professor, for his vigorous efforts for improvements. Both have provided additional productive criticism for this paper. Finally, I would like to thank the MAS IP team and all my fellow students for the enlightening and enjoyable time we spent together.