The Limits to IPR Standardization Policies as Evidenced by Strategic Patenting in UMTS

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Contents

1. Introduction ... 3
2. ETSI Standardization & IPR Policy ... 4
   2.1. GSM standardization ... 4
   2.2. Development of ETSI's IPR policy ... 5
   2.3. UMTS standardization ... 6
3. An Analysis of UMTS Patents ... 9
   3.1. Patent Data ... 9
   3.2. Measures of Patent Value ... 11
   3.3. Patent Timing ... 13
   3.4. Other Differences in Firm Patent Strategies ... 16
   3.5. Contrasting GSM and UMTS Patenting ... 17
   3.6. Data Limitations ... 21
4. Discussion ... 22
   4.1. Efforts to Reform ETSI IPR Policy ... 24
   4.2. Evaluating SSO Patent Policy Alternatives ... 25
   4.3. Future Research ... 30
References ... 30
Appendix A: Identifying Unique Patents and Citations ... 35
Tables and Figures ... 38

Tables and Figures

Table 1: Firms notifying essential UMTS patents at 3GPP member SSOs ... 38
Table 2: Patents by identifying patent treaty or country ... 39
Table 3: ETSI notified essential patents by firm ... 40
Table 4: Incoming patent citation analysis for 12 most active firms ... 40
Table 5: UMTS-specific patenting for the 12 most active firms ... 41
Table 6: Level of technological diversification ... 41
Table 7: Contrasting GSM and UMTS patent activity ... 42
Table 8: Patent share by stakeholder category ... 42
Table 9: Strengths and weaknesses of IPR coordination mechanisms ... 43

Figure 1: Timing of essential UMTS patents by leading manufacturers ... 43
Figure 2: Timing of essential UMTS patents by leading IPR firms ... 44
Figure 3: Essential patent portfolio size vs. firm telecommunications revenues ... 45

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Abstract: The impact of patents and patent royalties are a major concern of standards setting organizations. This study examines the patents filed in the standardization of UMTS, the third generation mobile phone technology developed under sponsorship of the European Telecommunications Standards Institute and others, using a patent policy developed in response to issues faced in the earlier GSM standardization. After contrasting firm strategies and policy effectiveness between the GSM and UTMS efforts, the paper reviews the potential impact of potential changes to the ETSI IPR policy.

Keywords: standardization, IPR policy, mobile phones, 3G, W-CDMA

1. Introduction

The management of patent royalties has become one of the most problematic and contentious areas of multivendor ICT standardization efforts. While standards setting organizations (SSOs) are organized around a presumption of cooperation toward a shared goal, the increasing role of patents in standards has also increased the divergence of stakeholder interests in standardization — between IP creators, equipment makers, service providers and end-users of standardized products. Although some SSOs have sought to manage standards-related patents or even ban them entirely, other SSOs seem to be in denial; all three approaches have serious limitations.

This study examines the nature and role of patents in one of the largest ICT standardization efforts of the past decade, that of the Universal Mobile Telecommunications System (UMTS), a 3rd generation mobile telephone standard. This standardization effort was governed by the IPR (intellectual property rights) policy developed in response to the difficulties faced handling patents during GSM standardization.

This study focuses on two main questions. First, how did firm IPR strategies used for UMTS compared to those used for GSM? Second, how well have SSO IPR policies coped with the increasing breadth and depth of patent portfolios?

The paper begins with a review of the standardization history and IPR policies for GSM and UMTS. It then analyzes the 1,227 unique patents claimed to be essential by 72 firms involved in the UMTS standardization effort. It discusses the interactions between the strategic patenting motivations and a firm's industry position. Finally, it discusses the limits as to the UMTS patent policy, and actual (or potential) proposals to reform that policy.

2. ETSI Standardization & IPR Policy

The standardization of UTMS[1] was both technically and institutionally a successor to that of the 2nd generation GSM (née Group Special Mobile). Much of the technical development took place at the European Telecommunications Standards Institute (ETSI), an outgrowth of the GSM standardization effort, and it involved many of the same telecommunications vendors and operators that led the early GSM effort. In particular, the UMTS standardization began with the IPR policy created by ETSI in response to problems encountered during GSM standardization.

2.1. GSM standardization

The initiative to create the first pan-European mobile phone standard began with the *Conférence Européenne des Administrations des Postes et des Télécommunications* (CEPT), the organization of all the major incumbent telephone operators. However, in 1988 the European Commission created ETSI to harmonize European telecommunication standards (Besen, 1990), and then pressured CEPT to transfer mobile phone standards efforts to ETSI. Operators remained in control of standards deployment through a group called the GSM Memorandum of Understanding (Bekkers, 2001).

As an initial IPR policy, the GSM agreement proposed a requirement that suppliers must grant operators a free worldwide license for all patents they held to implement GSM, and indemnify operators for all claims of patent infringement by third parties. However, the patent licensing policy was rejected by one of the largest IPR holders, Motorola, which was locked out of the U.S. market and faced high barriers from incumbent suppliers in the European market. Other manufacturers tacitly supported the Motorola stance, leading to defeat of the policy (Garrard, 1998; Iversen, 1999).

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1 UMTS (and related technologies) have also been called Wideband CDMA, W-CDMA, DS-CDMA and later 3GSM. For consistency's sake, but this paper uses the original UMTS name.

In response, most (but not all) operators substituted a requirement that all suppliers promise to provide IPR to the entire GSM community (both suppliers and operators) under "fair, reasonable and non-discriminatory conditions" (Bekkers et al, 2002: 179). In some cases, this FRAND clause was obtained by additional payments to suppliers.

Motorola agreed to these terms under limited conditions, and obtained only a handful of supply contracts. At the same time, it refused to license its IPR under royalty, but instead required cross licensing, eventually negotiating licenses with Siemens, Alcatel, Nokia and Ericsson (Garrard, 1998; Bekkers et al, 2002). These cross-licensing agreements provided a strong cost advantage for these five major patent holders, and created high barriers to entry by prospective GSM suppliers, with royalty rates for non-cross-licensees estimated at 10-13% (West, 2006).

2.2. Development of ETSI's IPR policy

After the rejection of GSM's proposed patent policy, ETSI made several attempts to develop its own IPR policy. Under heavy influence of operators, in 1993 ETSI proposed an IPR policy that firms were assumed to license IPR on a non-exclusive, FRAND basis unless they notify ETSI otherwise. Again this policy was abandoned in the face of informal and legal opposition (Iversen, 1999; Bekkers, 2001). In 1994, ETSI proposed what became its eventual policy, the so-called (F)RAND model that has been adopted by most formal standards bodies around the world. In brief, the 1994 ETSI IPR policy (which remains largely unchanged) is:[2]

- Holders of IPR, member or not, will be rewarded in a suitable and fair manner;

[2] These principles remain in the ETSI Rules of Procedures as published in November 2006 (ETSI, 2006).

- Members will make a reasonable effort to inform ETSI of relevant IPRs of which they are aware. If they propose a technical design to ETSI they will also, in good faith, draw attention to IPRs that could become essential[3] if that proposal is adopted;
- If an essential IPR is identified, the director of ETSI will request its holder, member or not, to make licenses available under (F)RAND terms;
- ETSI members can choose not to license an IPR. If no other alternatives exist, the director of ETSI will request the holder to revise its position. If a member refuses to do so, it has to inform the director about its reasons; this explanation will be passed on to ETSI's advisors (which include the European Commission). If no solution is found, ETSI may eventually halt the work on the standard or look for other technical alternatives that would not infringe upon the technology in question.
- To enable these policies, during each meeting of an ETSI Technical Committee, the participants are reminded that they should disclose possible IPR on the technical solutions that are being discussed.

2.3. UMTS standardization

UMTS standardization progressed in three important phases: exploratory research, formal standardization and standard implementation/refinement.[4]

Phase 1: Exploratory Research. The first activities related to UMTS began in 1990, prior to the launch of GSM. While the specific goals and technologies were not yet specified, there was a presumption that the 3rd generation standard would support mobile applications beyond just voice.

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[3] *ETSI (2004:44) defines essential IPR as* "it is not possible on technical … ground … to make, sell, lease, otherwise dispose of, repair, use or operate EQUIPMENT or METHODS which comply with a STANDARD without infringing that IPR."

[4] The complete details of the UMTS standardization are beyond the scope of this paper. This summary is adapted from Bekkers (2001) and Hillebrand (2003).

The earliest investigation was aided by R&D funding from the European Union. In particular, the 2nd Research and Development in Advanced Communications Technologies for Europe (RACE) program from 1992-1995 included specific grants for mobile phone technologies, one focused on CDMA and the other on extending an advanced TDMA technology developed during RACE-1 (1988-1992).

At the end of RACE-2, there was an effort to select one of the two competing technologies as the basis for UMTS, but the competition found no clear winner (Buitenwerf, 1994). While the program did not pick a specific technology, RACE-2 suggested eventual performance characteristics and also signaled to those outside RACE that development of a 3rd generation mobile standard had begun. However, the 3G developments were largely ignored by GSM operators, who were focusing on increasing subscribers of their existing 2G systems (Garrard, 1998, p. 478).

Phase 2: Drafting a Standard. Around 1995, more firms joined European UMTS standardization efforts. The EU budgeted 100 million ECU to Future Radio Wideband Multiple Access Systems (FRAMES), and contracts were won by Ericsson, Nokia, Siemens, France Telecom and various European universities. The EU also established a UMTS task force in 1995.

In 1996, Japan's Ministry of Post and Telecommunications (MPT) set up a group to study Japan's contribution to 3G standardization, including domestic operators, manufacturers, and key European, US and Korean manufacturers. Even before the group picked a technology, NTT DoCoMo placed an order with ten vendors for an experimental third-generation network, and announced a very aggressive further roll-out scheme, providing other Japanese actors with a fait accompli. The Association of Radio Industries and Businesses (ARIB) — a Japanese SSO — adopted the NTT choice and assumed further responsibility for developing the standard.

The Japanese activity accelerated European development of UMTS. As the official European telecommunication standards body, ETSI claimed the right to standardize UMTS. However, the European vendors split on which of the two RACE-2 derived technologies should become the standard: Nokia and Ericsson favored the wideband CDMA technology they had delivered as an experimental system for DoCoMo, while Alcatel and Siemens argued for a time-division TD/CDMA. After ETSI members were unable to pick a standard in 1997-1998, a compromise combining W-CDMA with elements of TD/CDMA was selected. This technology was soon endorsed by Japanese industry, and later ETSI and ARIB jointly founded the 3GPP (3rd Generation Partnership Project), which would eventually assume responsibility for UMTS standardization.

The UMTS standardization was delayed by an IPR fight between European vendors (particularly Ericsson) and Qualcomm, which owned dozens of CDMA patents believed relevant to the UMTS technology. Qualcomm was promoting a rival 3G standard (cdma2000) through a rival SSO (3GPP2), and sought changes to the UMTS specifications to make it easier to develop components that would support both 3G technologies. A group of operators eventually forced the parties to harmonize their specifications in 1999, and Qualcomm sold its network equipment business to Ericsson (Steinbock, 2001: 220-222; Mock, 2005: 199-209).

By the end of 1999, 3GPP completed the first complete draft of the specification, UMTS Phase 1, also known as “Release 99.” This defined the core of the UMTS standard, allowing vendors to develop products and operators to procure networks.

Phase 3: Implementation and Refinement. Beginning in 2000, European countries began to allocate UMTS licenses using two approaches, either “beauty contest” (government selection based on nominal merit) or an auction (highest price). In the latter case, the cost of licenses raises doubts about whether UMTS would ever be economically deployed.

Since the Release 99 standard, 3GPP and its member SSOs have produced additional versions of the UMTS standard. One area of greatest activity was in increasing data transmission rates, including the HSDPA and HSUPA high speed data extensions to the UMTS standard.

As with other mobile phone standards, the sale of UMTS-compatible equipment began with network infrastructure and then shifted to handsets. Carriers began to deploy UMTS networks beginning with Japan in 2001, through major Western European countries in 2003-2004, and in the US starting in 2007. Today, most handsets sold in Europe are dual mode GSM/UMTS compatible.

3. An Analysis of UMTS Patents

To understand the UMTS IPR situation — and to enable comparison to that of GSM — this section analyzes the patent ownership for UMTS. The data were compiled from UMTS standards-related patent declarations, cross referenced to other patent sources and databases.

3.1. Patent Data

The list of possible patents officially claimed essential for implementing UMTS can be obtained by studying the appropriate printed and online documents at the various standards bodies that participate in 3GPP: ARIB from Japan, ATIS from the U.S., CCSA from China, ETSI from Europe and TTA from Korea. Many of these participating firms made GSM-related declarations, since most UMTS infrastructure and terminal equipment provide backward compatibility for GSM and thus are affected by such IPR. The firms adopt a variety of patent declaration policies, which may be partly explained by the fact that firms are not always a member of all these standard bodies. A total of 72 firms claimed to own essential IPR either for the UMTS or the GSM standard (as indicated respectively in the first and last column of Table 1).

Insert *Table 1*

As described in Appendix A, the analysis reduced 6,313 UMTS patents from ETSI (2005) to 1,227 unique and essential patents, of which 801 patents were filed at the EPO (see Table 2). For those patents that were not filed under the EPO, the analysis used the U.S. or PCT patent numbers, which were available for 276 and 104 patents, respectively. The remaining 24 patent notifications were so incomplete that they could not be identified.

Insert *Table 2*

Table 3 provides an overview of the number of unique patents for the 37 firms listed in ETSI (2005). Nokia, Ericsson, Qualcomm and InterDigital Communications hold the largest patent portfolios, followed by eight firms that own between 15 and 86 patents each; the remaining 20 firms have notified five patents or fewer. Several of these patent portfolios reflected changes in corporate structure during the period 1980-2000, as when AT&T spinoff Lucent assumed patent licensing rights from AT&T (with its 6 GSM patents). Other examples included Qualcomm's acquisition of SnapTrack (and its patents), the InterDigital acquisition of SCS Mobilecom, and Nokia's purchase of the patent rights of the University of Sherbrooke. A few individuals account for a significant fraction of these patents, particularly Donald Schilling of InterDigital (225 EPO patents) and Klein Gilhousen (312) and Paul Jacobs (220) of Qualcomm.[5]

Insert *Table 3*

[5] Schilling was the founder of SCS Mobilecom, one of two firms merged in 1992 to create InterDigital. Gilhousen was one of the cofounders of Qualcomm, while Jacobs was the son of Qualcomm's first CEO who himself became CEO in 2005. Without comparable figures for other industries, it is hard to tell if these large number of patents reflect highly innovative researchers or merely a high rate of patenting.

Most firms in the sample have provided detailed patent notifications, but six firms note that they believe they own essential patents without specifying the number of patents or their details. These firms are labeled as “blanket claims” and excluded from most analysis.

3.2. Measures of Patent Value

Prior research has noted the difficulty assessing the value of any given patent (Sherry & Teece, 2004). In general, a patent is potentially more valuable if it is “essential” to a publicly available interoperability standard, because the patent holder can potentially block another firm’s attempt to implement that standard. When a firm holds a large number of essential patents, it will be difficult for a potential licensor to evaluate the value of each patent in the portfolio. To economize on transaction costs, some firms will seek to license their patents based on the number of patents, while others will attempt to define the value of their portfolio based on a small number of their most valuable patents (the “crown jewels”), such as patents that are so fundamental that they would be economically infeasible to invent around. An example of such a patent is one that provides the basis for an entirely new class of product or technology, as with the Hounsfield CT scanner patent (Trajtenberg et al, 2002). The holder of such a valuable patent may hold out for a higher-than-average valuation and royalty stream.

To allow for such variance, it would be useful to have an estimate of the value of the various UMTS patent portfolio — ideally, the market value of each patent, but such data is not reported. Theoretical measures of valuing individual patents have included development cost, income stream, increase in market capitalization, and by a “rule of thumb” royalty rate (Denton & Heald, 2003). The complexity of valuing a portfolio of patents incorporated in a standard is technically, legally and economically far more complex (Lea and Hall, 2004).

As a substitute, the analysis uses the number of times that a patent is cited by other patents, an estimate of patent value that has been validated by prior economics research

(Trajtenberg, 1990; Albert et al, 1991; Trajtenberg et al, 2002; Hall et al, 2005).[6] For the 1,227 patents, incoming patent citations from EPO and PCT[7] patents were measured using the OECD CitPat dataset.

Table 4 presents the results of the citation analysis: by any measure Motorola and Qualcomm have the highest scores. The average number of cites to their patents are 1.9 and 1.5 respectively, far above the overall average of 0.66 cites per patent.[8] The most valuable single patents seem to belong to Qualcomm; their EPO patent number 536,334 receives no less than 33 cites. No other firm scores higher than 12 incoming cites for a single patent. Following Trajtenberg (1990), a proxy was calculated for the value of a single patent to be one plus the number of cites it receives (i.e. the aforementioned Qualcomm patent would be worth 34). Replacing the ranking by the total number of patents by the newly calculated value proxy (presented in column 7), the most significant change is that Qualcomm would move from the third to the first position, and Nokia vice versa. By these measures, Qualcomm seems to hold the most valuable set of patents.[9]

Insert *Table 4*

A potential limitation of citation analysis is bias introduced by right truncation — which means that an older patent is more likely to be cited than a very recent patent — and thus such a biased analysis would undervalue the value of the patent portfolio of firms with the

6 Lanjouw and Schankerman (2001) found that the most valuable U.S. patents (as measured by forward citations) were also the most likely to be litigated.

7 "PCT" patents are named for the 1970 Patent Cooperation Treaty, and are reported at the World Intellectual Property Organization.

8 Qualcomm primarily uses its patents for licensing revenues (Mock, 2005) while Motorola historically used their for cross-licensing and licensing revenues (Bekkers, 2001). Blind et al (2007) found that such firms had lower quality patents than those patenting to prevent imitation, but the need for interoperability suggests that blocking imitators is not a practical goal for patents deemed essential for implementing a standard.

9 Note that patent quality and essentiality for a standard are not equivalent, nor are policy remedies similar. Patent reform often focuses on reducing the number of low quality (particularly obvious) patents (Jaffe and Lerner, 2004). Proposed reforms of SSO IPR policies tend to focus on removing patents (of any quality) that are not actually necessary for implementing a given standard, and on reducing royalties paid for use of the remaining patents.

most recent patents. In addition to such bias, the number of incoming citations of patents may also vary over time as a result of changing citation requirements by patent authorities, the “devaluation” of citations, or the effect of computer-aided searches for related patents. Furthermore, the number of incoming cites is also found to be related to the technological area in question (Jaffe and Trajtenberg, 2002).

To correct for these problems, the analysis uses the fixed-effects approach of Jaffe and Trajtenberg (2002: 436). Here, the number of incoming citations is compared to the average number of incoming cites of all patents in the same age cohort and in the same technology area. Age cohorts are constructed on the basis of priority year, and as expected, the average number of incoming cites in the cohorts drops over the years. The technology area of the reference group is defined using one of eleven possible technology subclasses as defined by International Patent Classification codes.[10] To calculate a corrected proxy for patent portfolio value, each of the incoming cites of each of the patents is first divided by the average of incoming citations in the corresponding age cohort. From this, all resulting scores of incoming cites for a particular patent and then across all patents of a given firm are added to create a firm total. The ranking of firms based on their truncation-corrected portfolio value (column 9) shows only minor differences from the unweighted value (column 7), suggesting that the latter is robust against truncation or secular timing trends.

3.3. Patent Timing

A key form of standards-related strategic patenting is when a firm deduces the direction that a standardization effort is proceeding and then attempts to create patents to read on that standard. One way such strategic patenting might be evidenced would be if the patents were filed well after the corresponding standardization effort had begun. The analysis used the

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[10] The specific IPC codes are discussed later for Table 6.

(earliest) priority dates of the 1,203 patents that could be identified (see Figure 1). More than the patent grant dates, these dates reflect the point in time at which the technology that is covered by the patent has been developed. These priority dates range from 1982 to 2002. There is a clear surge of patenting activities starting from 1990, with a peak in 1998-1999.

Insert Figure 1

In addition to the all patents, Figure 1 shows separate lines for the priority date for the patents held by Nokia and Ericsson. Both firms have rather identical patterns: there is a clear peak in patenting activity in the years 1998 and 1999, exactly the period in which the basic technology choice was made. Both firms were designing their (successful) proposal for that choice, and then involved in crafting the details of the standard within the relevant ETSI Technical Committees.

Interestingly enough, Qualcomm and InterDigital, the two other large IPR holders, show rather different timing patterns (see Figure 2). For Qualcomm, 199 of its 226 claimed essential patents were applied for in 1996 or earlier. That is years before the basic technology for UMTS was selected (in 1999). Although there is usually some delay between the priority date and the moment other parties can see the claims, when the UMTS technology was selected it was quite clear that Qualcomm owned an extensive portfolio of relevant patents. Also, Qualcomm was not involved in any of the proposals to ETSI (focusing on its competing cdma2000 technology instead) and was relatively absent when the standard was further set and drafted. Among the patents held by InterDigital, many were applied for long before the 1999 technology choice, though this company also shows more patenting activities in 2000 and 2001.

Insert *Figure 2*

Comparing incoming citations for the period before the surge with the data near the peak of the surge in 1998-1999, there is a drastic drop in patent quality. To correct for truncation problems, a new analysis took the ratio of incoming citations to those for other patents of the same age and patent classes. The 332 EPO patents with priority dates from 1982 to 1997 had on average 2.91 times as many citations as the industry average, while the 165 patents in 1998[11] had 1.07 times the industry average. Further analysis (not included) shows that the quality decrease is not gradual, but marks an abrupt drop in 1998 — matching the abrupt increase in patent filings. This implies that the later patents were of low quality and presumably incremental, while the older patents were more basic and more valuable.

The reasons for the surge in such apparently less innovative (yet "essential") patents are not directly observable.[12] Some possible explanations for the lower (age adjusted) patent citations for the later (post-1997) patents declared "essential":

- These later patents are based on applied rather than basic research, and thus is less valuable for subsequent (patentable) innovation.
- This work is more narrowly focused on a given technology class or subclass, and thus reads on a narrower range of technological development.
- The parties were "sitting at the table" while the detailed standard was being drafted, and thus were able to adopt a "tit-for-tat" attitude: if you let me to drive a trivial patent into the standard, I will let you do the same.

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11 Because of the lag in patent issuance and citations, the 2003 citation data did not produce meaningful results for patents filed in 1999 or later.

12 Given the high-stakes litigation over UMTS patents, a disinterested explanation of any party's motivations for patenting is unlikely to be publicly disclosed, particularly if the patenting is potentially "gaming" the system.

3.4. Other Differences in Firm Patent Strategies

There are other important differences between firms in their patent motivations and output — targeting of patents (towards the content of the standards) and technological diversity of the firm's essential patent portfolio

Targeting. Another measure of strategic patenting would be if a firm's patenting is primarily focused at a particular standardization effort (here UMTS) rather than more broadly on mobile telephony or telecommunications. This is considered by comparing their overall patent ownership in relevant mobile telecommunications categories with the UMTS essential patents that the firm owns. The analysis identified IPC codes that covered 97% of the essential patent data set, but omitted those IPC classes not specific to telecommunications (covering general electrical computing inventions or musical instruments, for example) which would distort the data for firms that are diversified in more product markets. The remaining 11 IPC codes (five at the subclass level, six at the more detailed group level) still cover 85% of all patents essential to GSM, and therefore these patent categories appear to be a good representation of inventions for mobile telecommunications.

For the 12 firms that rank highest on essential patent ownership (each holding more than 5 patents), the analysis identifies all patents in these categories that were published by the EPO through March 2005, as shown in Table 5, column (2). When compared to the share of essential UMTS patents published at EPO — as shown in column (4) — there are two clear outliers. Both InterDigital (93%) and Asustek (92%) disclose nearly all of their mobile telecom patents filed at EPO as UMTS essential patents, a strong indication that their patenting activity was specifically directed to inventions that would become implemented in UMTS. The third highest score is for Qualcomm, of which 22% of the patents in this field are essential to UMTS. For all other firms, the ratio is 10% or less. One explanation might be that of a firm's global innovations, only the patents relevant to European use (in this case GSM or

UMTS) are patented in Europe. When the essential patents are compared to the mobile telecommunications patents held in the U.S., it reduces the ratio for InterDigital, but both it and Asustek remain outliers.

Insert Table 5

Technological Diversity. A third difference between firms is the degree to which patents held by a particular firm relate to many different technical aspects of the standard or whether all patents relate to the same part of the standard. This is a measure of how diverse the overlap is between a firm's patent portfolio and the standard (cf. Granstrand et al, 1997).

Diversification was measured through the standards deliverables for which the patents were deemed essential, as indicated in the notifications. The UMTS standard is made up of hundreds of deliverables, classified in 15 main series. These series cover different technical areas, such as radio aspects, (speech) codecs and security (see Table 6). Some series comprise (much) more patents than others, mostly because of differing nature of the technology. Overall, most of the essential patents that are in the database are indicated to be relevant for the 25 series ("radio aspects"; 38% of all patents); the 21 series ("requirements", 25% of all patents) and the 23 series ("technical realization", 13% of all patents). All other series comprise less than 10% of all patents. These results indicate that Siemens and Nokia are most diversified, whereas the patents of firms like InterDigital, Motorola and Asustek are in one very narrow area (one or two series only).

Insert *Table 6*

3.5. Contrasting GSM and UMTS Patenting

The UMTS patenting should be considered in comparison to the patenting activities in the earlier GSM era (as reported by Bekkers et al, 2002). Together, both the increase and distribution of patenting in UMTS suggest learning effects from the seminal use of strategic patenting in the era effort.

Table 7 compares the number of patent and patent holders, the concentration of patent rights, and the share of patents produced by various categories of industry stakeholders.

Insert Table *7*

The most obvious change is a dramatic increase in the number of essential patents and the number of patent-holding firms. The patent portfolios are compared for each standard at a point approximately six years after the standard was frozen in 1990 (GSM) and 1999 (UMTS), respectively: these portfolios include both patents essential to the first version, and those essential to later improvements or enhancements added to the official standard. After six years, GSM had a total of 140 essential patents held by 23 organizations. For UMTS, the comparable figures are 1,227 essential patents (an eightfold increase) held by 72 organizations (a threefold increase).

As the number of firms holding essential IPR has grown threefold, one might expect that the concentration of the essential patents would have decreased over time: this could be tested using the concept of the CR4 and CR8 concentration ratios, but applied to patent share rather than market share. For GSM, the CR4 patent ratio (the proportion of all essential patent held by the four largest patent holders) equals 52%, while that same ratio for UMTS is 72%; for the CR8 patent ratio, it is 73% for GSM and 91% for UMTS, respectively. The Hirschmann-Herfindahl-Index (HHI) reveals a similar pattern, rising from 0.30 to 0.38. Contrary to intuition, this suggests that IPR holdings have become more concentrated despite the increasing number of patent holders.

Finally, an individual patent may play a different role depending on how it fits the firm's strategies and business models. While firms often patent to assure the exclusive right to commercialize an invention, other reasons include preventing rivals from making related products, defensive patenting (deterring patent infringement lawsuits or providing leverage for negotiating cross-licenses), obtaining licensing revenue and boosting the firm's reputation. (Cohen et al, 2002; Blind et al, 2006). These additional motivations are often referred to as "strategic patenting"; as Teece (1986) observe, a firm's use of IPR will depend on its position relative to competitors and whether it possess key assets (such as market access) necessary to commercialize its innovation.

Insert *Figure 3*

The firms in the sample differ considerably in their size and portfolio size, as shown in Figure 3.[13] Most of the largest patent holders in the sample appear to use patents to deter rivals, provide leverage for cross-licensing or to earn licensing income. In the UMTS and GSM databases, there are six categories of firms based on their position in the industry. Firms in each category have different patent strategies:[14]

- *Established supplier,* those ranked in the top 10 for market share for the earlier generation of technology. Usually, such firms use a defensive patenting strategy to have the freedom to access the necessary IPR of other parties. To reduce transaction costs, they often conclude cross-license agreements, unless the other party has too few patents (or too high a volume) to make a patent transfer without monetary compensation appropriate.

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[13] To provide comparable sales figures, the figure uses the Electronics Communications Related Turnover used by ETSI to calculate membership dues: firms have an incentive not to overstate such revenues, while their competitors have an incentive to monitor attempts to understate these revenues.

[14] Diversified companies may overlap more than one category. Vertically integrated firms, are assigned to the downstream category (e.g. an IP and component producer would be treated as a component company; a component and handset maker would be treated as a handset maker). However, AT&T's GSM patents were imputed to its equipment division, reflecting its subsequent attempts to sell infrastructure to European operators rather than its U.S. fixed line operations.

- *New entrant.* These producers plan to enter the mobile telecommunications equipment market, and to use their own patents to strengthen their negotiation position for obtaining other necessary IPR.
- *Network operator.* These are largely the successors to the government-owned operators that once funded national R&D laboratories, but have in the past decade have scaled down such operations. The exceptions to this pattern are NTT and its former subsidiary NTT DoCoMo.
- *Component supplier.* A minor factor in GSM, for UMTS two semiconductor producers (Qualcomm and Phillips) had large patent holdings.
- *Technology developing and licensing firm.* The main business models of these firms are to develop and license IPR. Because they do not make products, they do not need access to the IPR of other firms, and thus such IPR cannot be used as a "bargaining chip" to reduce their license fees.
- *Adjacent technology developer.* These firms developed and patented technology for other applications, and later saw that technology used an essential part of a mobile standard. Usually, these firms had no strategic intent related to that standard, but welcome the incremental licensing income; unlike component suppliers, these firms do not supply components or code to other firms in the value chain.
- *Other.* These otherwise unclassified organizations include public research organizations in Korea and Taiwan.

A comparison of the share of essential IPR for these different categories suggests interesting differences between GSM and UMTS (Table 8). The most significant rise is that of the market share of the component suppliers and the technology developing and licensing firms. The share of IPRs of these two categories together grew from less than 5% to almost 37%. The biggest reduction of patent share is for the network operators and the adjacent technology developers: their share dropped from around 30% to less than 1%. As shown in Table 7, the geographical distribution of firms (Europe, U.S., Japan, and other regions) has not shifted much, despite the major Japanese involvement in UMTS and a more global orientation.

Insert Table 8

3.6. Data Limitations

The data may understate or overstate the number of essential UMTS patents. The data includes only those organizations that voluntarily self-disclose their IPR through ETSI or other UMTS standardization bodies. Among those firms identified, only limited conclusions can be drawn about those firms (particularly Lucent, NEC and Texas Instruments) that offer only a “blanket” disclosure: there is no way to tell if these firms have one relevant patent or 50. The analysis has only limited conclusions about IPR declared outside ETSI (2005), particularly those organizations that declared their IPR only with ARIB (1998, 2000).

The analysis allows for the interdependency of GSM and UMTS technology, but not the complex interdependency of the 3GPP (UMTS) and 3GPP2 (cmda2000) efforts, which overlap both in organizational membership and relevant IPR. It also excludes patents for technologies that originate outside the telecommunications industry — such as video compression (e.g. MPEG-4) or digital rights management — that will become commercially relevant for makers of mobile handsets.

The use of self-disclosed essentiality almost certainly overstates essentiality. The only study in the public literature (Goodman & Myers, 2005) sampled one patent from each of 887 patent families of the 3GPP and 3GPP2, concluded that only 21% of the overall 3G patents were essential; however, their single-rater findings on a sample of patents have not been independently replicated. Another study of 3GPP declared patents found that only 37% (794 of 2166) patents or patent applications were essential (PA Consulting 2007), but that study is sold to its clients rather than being openly distributed. However, such studies are only estimates because essentiality can only be determined in a court of law: recent litigation has asked courts to declare that some UMTS patents are not actually essential as defined by ETSI.[15]

Finally, the analysis uses only indirect measures of patent value, due to significant theoretical and practical issues. The current market price of UMTS patents are being established by confidential dyadic negotiations, with a small fraction of the patents being the subject of multimillion dollar court challenges. Needless to say, the difficulty of valuing such patents remains a source of ongoing uncertainty and controversy in the telecommunications industry.

The impact of the far smaller GSM patent portfolio identified by Bekkers (2001) were not publicly visible until more than a decade later: in response to Ericsson's 2005 lawsuit, U.K. startup handset maker Sendo alleged to the European Commission that the GSM patents held by the major European makers constituted an illegal cartel intended to keep out new entrants. One firm has estimated that non-IPR holders pay 10-13% royalties for GSM, and 20% for UMTS (West, 2006; PA Consulting, 2002). Meanwhile, an undetermined number of firms reduce or avoid royalties through cross-licenses.

4. Discussion

By comparing the nature and number of patents for Europe's 2nd and 3rd generation mobile telephone standards, this study shows the following changes:

- An eightfold increase in patents (140 to 1,227) and a threefold increase in patent holders (23 to 72);

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15 For example, a July 2005 UK lawsuit by Nokia alleged that 31 patents declared by InterDigital were not essential to UMTS, and prior to trial InterDigital dropped essentiality claims for 26 patents.

- Despite the latter increase, the ownership of patents has become more concentrated, which suggests increasingly strategic patent use by a small proportion of firms;
- Although the ETSI-led standardization effort has become more global, allowing new entrants into the European market, there have been only minor changes in the total share of patents held by Europe, North American and Japanese firms, and between incumbent and new equipment providers; and
- A dramatic decline in the patent creation by operators and concomitant increases in the role of component suppliers and technology licensing firms.

The sources of UMTS patent proliferation have often been ascribed to IPR-focused companies outside the ETSI process, particularly Qualcomm and InterDigital. However, this study shows that the largest number of patents are held by two firms (Nokia and Ericsson) centrally involved in the UMTS standardization, and the timing of their patenting suggests that they used their knowledge of the standard's development for anticipatory patenting — further contributing to patent proliferation.

Still, a cozy oligopoly of four main UMTS patent holders might have produced a manageable IPR regime comparable that to the five major holders of GSM patents. However, the number of firms claiming at least a one patent has grown threefold, increasing the risk of holdup, transaction costs and royalty stacking[16] for firms implementing the newer standard. This uncertainty is magnified by the self-determination of essentiality: while it's virtually impossible to determine how many of the 1,227 patents are actually necessary to implement UMTS, conversely other parties fail to provide an itemized list of essential patents.

[16] Lemley & Shapiro (2007: 1993) define it precisley: "The term 'royalty stacking' reflects the fact that, from the perspective of the firm making the product in question, all of the different claims for royalties must be added or 'stacked' together to determine the total royalty burden borne by the product if the firm is to sell that product free of patent litigation."

4.1. Efforts to Reform ETSI IPR Policy

ETSI's 1994 IPR policy were intended to solve the IPR conflicts that it had faced in GSM, and this policy was in force during the entire UMTS development process. However, it was criticized by ETSI members for being ineffective in limiting the problems caused by a proliferation of patent claims and patent holders. In 2005, twenty of the largest operators and suppliers in the field of mobile telecommunications (Alcatel, BT, Vodafone et al, 2005) listed the following concerns:

- Deferred IPR declarations lead to agreement on standards without members knowing all IPR involved.
- 'FRAND' is not sufficient. The lack of definition of commercial terms has resulted in unsustainable demands. Royalty obligations are inaccessible for an evaluation of whether they are fair, reasonable and non-discriminatory.
- Cumulative patent royalties ("royalty stacking") can raise the license burden to an extent unbearable to the industry.
- Lack of IPR transparency through unfiltered publishing of thousands of patent declarations, further compounded by bundling of patents in portfolios.
- Lack of active IPR management. SSOs generally do not actively manage IPR: no essentiality check for patents declared, no IPR intelligence, no IPR issue resolution, no policing of IPR rules, no sanctioning of non-compliance.

In response to these concerns, in 2005 ETSI established an ad hoc IPR Review group to provide advice to the ETSI General Assembly. This IPR group had three (closed) workshops, with dozens of members participating. The workshop identified a wide range of reforms, ranging from patent landscaping (identifying possible IPR prior to standards selection) and patent pools, to more drastic fixes, such as mandatory ex ante licensing. The ad hoc group finished its work in November 2006. Outside sources indicate that consensus could not be reached around most of these proposals (see ATIS, 2006).

Not surprisingly, then, the report and advice of the IPR review ad hoc group included only incremental changes: most of its 16 recommendations relate to clarifications and smaller issues for the IPR policy and related ETSI documents. More substantial activities, such as collective licensing arrangements, patent pools and IPR landscaping would be considered as 'an activity outside of ETSI'. Many issues were deferred with the recommendation to create a permanent 'IPR Committee'. Further clarification of RAND and addressing the problems of cumulative licensing were among the issues deferred to this new IPR Committee (ETSI, 2006).

While the IPR Committee continues, the fact is that two years of ETSI discussion brought only minor changes to its IPR policy. The difficulty of addressing what is perceived to be a major problem suggests that ETSI has difficulty achieving consensus on more specific IPR policies across the broad range of ETSI member interests. As with its 1994 policy, ETSI appears to be a leader in standardization practice, and thus its problems will all face many other SSOs. In fact, responding to the ETSI discussion, other standards bodies such as ATIS began considering reforms as well (see ATIS, 2006).

4.2. Evaluating SSO Patent Policy Alternatives

Going forward, what policies are available to ETSI and other SSOs to reduce the impact of strategic patenting upon cooperative standardization? The key concerns facing producers and consumers are search costs (SC), transaction costs (TC), IPR costs (IC) and the holdup risk (HR). [17] IC and HR are potentially zero-sum allocations, in that costs to implementers become income to patent holders; SC and TC produce no corresponding benefit to patent

[17] The choice of alternatives may also be constrained by competition policy; Shapiro (2003) reviews the alternatives and the competitive implications.

holders, except to the extent that ambiguity over the value of a patent portfolio allow an IP holder to command a higher price.

Table 9 shows the eight most commonly suggested alternatives, which differ in the degree to which they address four different potential forms of innovation drag.:

Insert Table 9

Patent Pools. Patent pools have the potential to reduce coordination costs that hinder adoption, and can be pro-consumer if they are confined to essential patents that are mutually complementary (Lerner and Tirole 2004). However, patent pools have been shown to fail when the primary motivation is to cap royalties (INTEREST, 2006). Consideration of the patent pool incentives suggests a related, fundamental problem: assigning exclusive control of the right to license one's IPRs requires a strong alignment of interests of the IPR holders. When there is competitive heterogeneity between the firms' product and IPR positions, it will be difficult for patent pools to attract (or maintain) broad enough participation necessary to make a significant patent pool.

Royalty Free. In this licensing policy, standard bodies (or other organizations) require that all licenses for essential patents are made available free of charge; such a policy may also be imposed as part of government procurement rules. Royalty-Free licensing is now the rule at some standards bodies, including W3C, but it is not practical if even a few firms are unwilling to license their IPR. Such a policy has not been successfully implemented for standards (such as mobile telecommunications) where participants have heavily invested in R&D and that see licensing income (or bargaining chips) as an essential part of their business strategy. A proposed modification to Royalty Free is Non-Assertion After Specified Time, in which IPR holders pledge to make their patents available Royalty Free after predeclared delay (Rysman and Simcoe, 2007).

Non-Assertion Covenants (NAC). These agreements are equivalent to conditional promises of royalty-free licensing, i.e. a pledge not to charge licensing fees for essential IPRs provided that other firms also do likewise. The successful NAC can thus defuse the IPR question altogether, both for parties to the standards activities as well as for third-parties. Recently, NACs in the field of open document standards have been issued by both Sun Microsystems and Microsoft (INTEREST, 2006). The inherent weakness of NACs, however, is that the threat to waive royalties are unlikely to influence IPR-only firms whose business models depend on licensing revenues and do not produce products that need licenses from other participants.

IPR Landscaping. In this approach, an extensive effort is made to identify all IPR relevant to a proposed technological approach. The decision to adopt the technology in question then is made dependent on the number of essential patents founds, and an assessment of the conditions of their availability. When practiced by (or on behalf) of a standards organization, this breaks with the traditional attitude of SSOs that they are in no way responsible for patent searches.

Ex-Ante Licensing Terms. Taking landscaping one step further, here firms with identified essential IPR are asked to communicate their licensing terms and conditions, in particular the licensing fees. R&D intensive firms strongly oppose such an obligation, arguing that market size and other uncertainties make it impossible to commit to certain conditions at the initial phase of standards development.

Technological Competition. Market competition could provide another check upon licensing terms. For example, recently threats by Chinese manufacturers to develop their own videodisc standard has reduced the royalty rate demanded by the Japanese and U.S. owners of DVD patents (INTEREST, 2006). In telecommunications, China has used the prospect of its homegrown TD-SCDMA 3rd generation standard to encourage lower royalty rates for deploying UMTS or cdma2000 networks within its borders. Credible competition exists between 3G standards also exists in the US, Japan and Korea, but not in Europe, where European Union industrial policy has mandated a single pan-European mobile telephone standard since GSM.[18] This requirement made both GSM and UMTS attractive targets for firms (either inside or outside the standardization process) utilizing strategic patenting in hopes of extracting rents.[19] Beyond regulatory effects, positive network effects and switching costs enjoyed by established standards may also limit actual technology competition, particularly with the large standard-specific investments required for mobile infrastructure While telecommunications industries have tended towards a single standard, the experience of the computer industry demonstrates that it is possible to simultaneously implement competing standards and then eventually phase out the less popular standards. The use of adaptability — negotiated compatibility between multiple implementations — would facilitate the co-existence of multiple standards and the eventual retirement of less popular ones (Krechmer, 1996).

Direct Regulation. Another approach is through direct government intervention, such as through anti-monopoly law. In 2005, six of Qualcomm's competitors asked the European Commission to interpret ETSI IPR policies as limiting Qualcomm's UMTS royalty rate. However, such a dispute could easily become a trade issue: one of the most vocal critics of high royalties has been the U.K. operator Vodafone, while two of the greatest beneficiaries of royalties have been the U.S. firms Qualcomm and InterDigital. Thus, attempts by one government to impose compulsory licensing terms could be resisted by another government,

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18 While a single standard would be expected to enjoy economies of scale, market selection between competing standards would be expected to provide competition on technology, price or both (Gandal et al, 2003).

19 In a technical subfield with an above average number of SSOs, Chiao et al (2007) demonstrated conscious efforts by SSOs to compete for sponsors by making a consistent set of choices either favoring or restricting the IPR flexibility of sponsoring companies.

leading to potential trade conflicts (as occurred temporarily during the Qualcomm vs. Ericsson disagreement over UMTS licensing terms in 1998-1999).

Royalty Caps. As noted earlier, attempts to negotiate voluntary cooperation to "cap" royalties have thus far failed. The various parties would appear to have divergent interests: while the business model of manufacturers (Nokia, Ericsson, NEC, Lucent) depends on equipment sales, that of IPR-focused companies (notably Qualcomm and InterDigital) is heavily dependent on IPR royalties, and the interests of operators (BT, Vodafone, NTT, Telia) are to minimize the amount spent with either party. Some parties have called for standards bodies to impose royalty caps on their standard.

Two of these approaches were attempted by UMTS participants to limit IPR costs. The first approach was a patent pool, which was initially known as the 3G Patent Platform Partnership (3G3P) and later 3G Licensing. After receiving positive business review letters from the U.S. Department of Justice and the equivalent European and Japanese competition authorities in 2002, the pool established a joint licensing program in 2004 (3GPatents 2004). In 1999, 49 firms were involved the pool, while as of 2006 only nine firms had pledged their IPR (INTEREST, 2006; 3G Licensing 2006). Among these nine is only one (Siemens) of the ten largest patent holders, so the pool has thus far had only a minimal impact on search, transaction or IPR costs.

The other approach that was tried was to directly cap cumulative patent royalties. The earliest plan for the 3G patent pool proposed a 5% royalty cap (Franzinger, 2003). Again in May 2002 Nokia sought to cap total UMTS patent royalties at 5%. But in the end, Nokia won support for this proposal only from DoCoMo and three European manufacturers. Some other European and Asian manufacturers — as well as some operators — backed the competing 3G Licensing pool. Major North American participants in UMTS standardization (Qualcomm, Lucent, Motorola, Nortel, TI) joined neither camp (West, 2006).

For the 3GPP's proposed 4th generation mobile standard, Long Term Evolution (LTE), in April 2008 key vendors and users proposed establishing a patent pool and "single digit" royalty cap. The proposal was supported by leading European and Japanese equipment makers (including Nokia and Ericsson), but missing from the proposed patent pool were the four major North American patent holders: Qualcomm, InterDigital, Motorola and Nortel.[20] While the LTE pool would appear to include a greater proportion of patents than did UMTS pool, the proposals do not appear to solve the fundamental business model conflict of the earlier UMTS (and GSM) efforts — the conflict between those who charge patent royalties and those who pay them.

4.3. Future Research

Future research should consider the issues of patent proliferation under different policy regimes. For example, patent pools have been assembled for consumer electronics standards such as MPEG-4, HD DVD and Blu-ray. It's an open empirical question as to whether these efforts been more successful in managing patent proliferation, licensing and transaction costs — and, if so, whether it has been through stronger mechanisms for aligning participant interests, or through controls that limit the number of members firms (and thus patent claimants). Also, research should more carefully consider the root causes for policy failure: it may be that agreement is only possible when interests are already closely aligned.

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[20] A patent pool and royalty cap were also proposed in June 2008 by supporters of a competing 4G technology, WiMax, but only one of the LTE pool participants (Alcatel-Lucent) and none of the LTE holdouts endorsed the effort.

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Appendix A: Identifying Unique Patents and Citations

The list of 1,227 unique patents used in the analysis of this paper was developed from multiple sources. The patent data consisted of the list of printed and online lists of essential patents (as declared at the standards bodies listed in Table 1) and the actual UMTS patents themselves, as filed in multiple jurisdictions.

Unfortunately, not all the sources are complete or consistent enough to allow for a detailed analysis. Therefore the analysis considers only those patents disclosed through the most reliable dataset available (ETSI 2005), a 2,427 page report listing 13,106 patent notifications. This study used the 6,313 patents (from 37 firms) relating to UMTS, and not those relating to other ETSI standards such as the TETRA mobile radio standard. For this analysis, GSM patents are included only if they are notified as claimed to relate to the UMTS standard.

However, there is the possibility of double counting if an IPR holder applies for different patents on the same innovation in different national jurisdictions. There may also be registrations at the European Patent Office (EPO) or be PCT patents reported at the World Intellectual Property Organization (designated by the prefix "WO"). Also, the same innovation may be listed more than once, at different ETSI projects related to UMTS. Such double counts have been removed using the patent application number and the patent numbers. These patent numbers were translated from their various filing jurisdictions using a variety of sources, including the EPO's MIMOSA patent database. The patent citation dataset developed by OECD proved to be particularly useful for identifying equivalent patents, even though it was originally designed for another purpose. Its main drawback, however, is that it only includes (granted) patents with application dates up to the year 2001.

The data also included online patent data sources, notably the Esp@ce service of the EPO and the patent search services of the U.S. Patent Office (USPTO), the WIPO, and those of the Japanese Patent office. The data reduction is not a trivial task, since identical patents may be notified using totally different names while sometimes different patents do share the same name. Also, the data provided are often incomplete, inconsistently coded and contains numerous typographic errors (both in their titles and their numbers). The analysis included all the notified patents, regardless whether they were already granted or still pending.

Duplicate incoming patent citations were also possible. When analyzing the EPO and PCT patents citations, some citations refer to a national patent number. This was corrected by applying a correspondence table from national to EPO (or PCT) patents, and then eliminating redundant citations. Due to this correspondence problem, and because the OECD database includes patents “only” up to 2001, the data may omit some relevant citations.

The interpretation of patent citations differs by jurisdiction. U.S. applications are obliged to provide the relevant references to other patents or literature, whereas in Europe this is optional. Criscuolo and Verspagen (2005) estimate that applicant citations in the EPO are roughly 15% of those under the US system, in part because the latter system penalizes inventors with incomplete citation lists. Thus, a patent citation analysis on the basis of European patents provides a more conservative (and likely more precise) estimate of the impact of a given patent.

Tables and Figures

Table 1: Firms notifying essential UMTS patents at 3GPP member SSOs

Notifications at: *Concerning (6):*	*ETSI online IPR database (1)* *UMTS*	*ETSI SR314 (2)* *UMTS*	*ARIB(3)* *UMTS*	*ARIB(4)* *UMTS*	*ATIS(5)* *UMTS*	*ETSI online IPR database (1)* *GSM*
1. Aepona	x	x				
2. Alcatel	x	x				x
3. ASUSTeK	x	x				
4. Axalto	x					
5. Bijitec	x	x				
6. Broadcom	x					x
7. BT						x
8. Bull CP8						x
9. Canon	x	x	x			
10. Casio			x	x		
11. CCETT	x					
12. CCL/ITRI	x	x				
13. Cellnet						x
14. Cisco Systems	x	x				
15. Coding Technologies	x	x				
16. DDI				x		
17. De Te Mobil						x
18. Ericsson	x	x	x			x
19. ETRI (Korea Telecom)	x	x				
20. EVOLIUM	x	x				x
21. France Telecom	x	x				x
22. Fujitsu Limited	x		x	x		
23. Gemplus						x
24. Golden Bridge Technology	x		x	x		
25. Hitachi	x					
26. Huawei Technologies	x					
27. Hughes Network Systems	x					
28. Innovatron						x
29. Intel	x					
30. InterDigital	x	x				x
31. IPR Licensing	x	x				
32. Italtel Spa	x	x				
33. KDD			x			
34. Kineto Wireless					x	
35. Kokusai			x			
36. KPN	x					x
37. Lucent/AT&T	x	x			x	x
38. Lupa Finances						x
39. Matra						x
40. Matsushita/Panasonic	x		x	x		
41. Media Farm	x	x				
42. Mitsubishi	x	x	x	x		x
43. Motorola	x	x	x	x		x
44. NEC Corporation	x	x	x	x		x
45. Nokia	x	x	x	x		x
46. Nortel Networks	x	x				x
47. NTT	x		x	x		x
48. NTT DoCoMo						
49. OKI Electric Industry	x	x	x	x		
50. Omnipoint	x	x				x
51. Orange	x					x
52. Philips	x	x				x
53. Qualcomm	x	x	x	x		x
54. Robert Bosch	x	x				x
55. Rockwell						x
56. Salbu Research & Development	x	x				
57. Samsung	x	x	x	x		x

Notifications at: Concerning (6):	*ETSI online IPR database (1) UMTS*	*ETSI SR314 (2) UMTS*	*ARIB(3) UMTS*	*ARIB(4) UMTS*	*ATIS(5) UMTS*	*ETSI online IPR database (1) GSM*
58. Schlumberger Systèmes						x
59. Sharp			x			
60. Siemens	x	x	x	x		x
61. Sony			x	x		
62. Sun Microsystems	x	x				x
63. Tantivy Communications	x	x				
64. Télédiffusion de France	x					
65. Telia (Telia Sonera)	x	x				x
66. Texas Instruments	x	x		x		x
67. Toshiba	x	x	x	x		x
68. University de Sherbrooke			x			
69. Vodafone/ Libertel/ Airtouch	x					x
70. VoiceAge	x	x				
71. Voicecraft			x			
72. Wi-Lan	x	x				
Total number of firms notifying	52	37	22	17	2	36

Notes:

(1) IPR in ETSI deliverables, as available from www.etsi.org, as of September 28th, 2005.
(2) ETSI SR 000 314 V1.14.1 (2005-04) Special Report, Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards.
(3) Notifications in document ARIB STD-T63 Ver 1.00 'List of Essential Property Rights (IPRs) for ARIB STD-T63 ' IMT-2000 DS-CDMA system' (probably from October 2000)
(4) Notifications in 'Japan's Proposal for Candidate Radio Transmission Technology on IMT-2000: W-CDMA', ARIB, June 1998
(5) Notifications in ATIS Patent Information, consulted November 2005 at www.atis.org/tc/patpolicy.asp
(6) GSM refers to any GSM, GPRS or DCS-1800 patents; UMTS refers to any UMTS/3GPP patents

Table 2: Patents by identifying patent treaty or country

Patent identification	*Claimed number of unique essential patents*
European Patent Office (EPO)	801
U.S. patent *(no EPO equivalent)*	276
Patent Cooperation Treaty (PCT) / World Intellectual Property Organization (WO) *(no EPO or U.S. equivalent)*	104
Japan *(no EPO, U.S. or PCT equivalent)*	8
Canada *(no EPO, U.S. or PCT equivalent)*	5
Germany, Finnish, French, English, Danish or Norwegian patent only *(no EPO, U.S. or PCT equivalent)*	9
Unidentified	24
Total	1227

Source: own analysis of ETSI (2005)

Table 3: ETSI notified essential patents by firm

Firm	*Claimed number of unique essential patents*
Nokia	248
Ericsson	244
Qualcomm	228
InterDigital	168
Samsung	86
Motorola	54
Philips	45
Siemens	38
Asustek	23
Alcatel	20
Mitsubishi	18
Nortel	15
Toshiba, ETRI, Voiceage, France Telecom, Evolium, Sun Microsystems, OKI, Tantivy communications, IPR licensing, Salbu research & development, Cisco systems, Robert Bosch, Canon, CCL/ITRI, Media farm, Aepona, Bijitec, Wi-lan, Telia	Each claiming 5 or less patents
Coding technologies, Italtel, Lucent, NEC, Omnipoint, Texas instruments	Blanket claim

Source: ETSI (2005)

Table 4: Incoming patent citation analysis for 12 most active firms

Firm (1)	*Total number of patents (2)*	*Total number of incoming cites(3)*	*Average number of incoming cites per patent (4)*	*Max received cites per patent (5)*	*Proxy of the patent portfolio value (6)*	*Rank patent portfolio value proxy (7)*	*Weighted patent portfolio value (8)*	*Rank weighted patent portfolio value proxy (9)*
Nokia	248	83	0.33	6	331	3	233.9	3
Ericsson	244	182	0.75	9	426	2	319.0	2
Qualcomm	228	339	1.49	33	567	1	475.2	1
InterDigital	168	18	0.11	4	186	4	27.1	6
Samsung	86	20	0.23	12	106	6	31.0	5
Motorola	54	103	1.91	13	157	5	74.9	4
Philips	45	32	0.71	9	77	7	22.1	7
Siemens	38	3	0.08	1	41	8	9.2	10
Asustek	23	0	0.00	0	23	11	0.0	12
Alcatel	20	10	0.50	8	30	9	17.7	8
Mitsubishi	18	6	0.33	4	24	10	11.1	9
Nortel	15	8	0.53	4	23	12	5.0	11

Table 5: UMTS-specific patenting for the 12 most active firms

Firm	Unique essential patents notified at ETSI (1)	All mobile telecom related patents in EPO (2)	All mobile telecom related patents in USPTO (3)	ETSI:EPO ratio (4)	ETSI: USPTO ratio (5)
Nokia	248	2,591	2,330	10%	11%
Ericsson	244	2,386	3,672	10%	7%
Qualcomm	228	1,047	1,079	**22%**	**21%**
InterDigital	168	181	375	**93%**	**45%**
Samsung	86	1,016	1,317	8%	7%
Motorola	54	1,144	4,497	5%	1%
Philips	45	1,493	1,535	3%	3%
Siemens	38	2,590	1,719	1%	2%
Asustek	23	25	17	**92%**	**†135%**
Alcatel	20	2,027	1,780	1%	1%
Mitsubishi	18	439	814	4%	2%
Nortel	15	921	1,662	2%	1%

Note: Ratio values larger than 0.20 are printed bold. Mobile telecom patents in (2) and (3) are patents in IPC categories G01S1, G01S5, H01Q21, H01Q3, H04B, H04J, H04K1, H04L, H04M, H04N1 or H04Q
(1) Notification filed at ETSI according to an analysis based of ETSI SR 000 314 V1.14.1 (2005-04)
(2) Patent filed at the EPO on or after 1 Jan. 1983 and published by 28 Feb 2005.
(3) Patent filed at the USPTO on or after 1 Jan. 1983 and published by 24 January 2006.
(4) Ratio of (1) to (2)
(5) Ratio of (1) to (3)
† Asustek notified ETSI of 12 patents filed with EPO without an USPTO equivalent.

Table 6: Level of technological diversification

Firm	Number of different specification series in which patents are notified (1)	Diversification measurement (corrected for portfolio size) (2)	Main series (3)
Nokia	11	4.59	25, 23, 26, 24, 29
Ericsson	0	no data	no data
Qualcomm	5	2.12	22, 23, 24, 25
Interdigital	1	0.45	21
Samsung	3	1.55	25
Motorola	1	0.57	21
Philips	2	1.20	25
Siemens	8	5.03	25, 23
Asustek	1	0.72	25
Alcatel	2	1.51	25
Mitsubishi	3	2.35	25, 26
Nortel	3	2.49	25

UMTS specifications series:
- 21: Requirements
- 22: Service aspects
- 23: Technical realization
- 24: Signaling protocols - user equipment to network
- 25: Radio aspects
- 26: CODECs
- 27: Data
- 28: Signaling protocols
- 29: Signaling protocols - intra fixed network
- 30: Program management
- 31: Subscriber Identity Module (SIM / USIM)
- 32: OAM&P and Charging
- 33: Security aspects
- 34: UE and (U)SIM test specifications
- 35: Security algorithms

Note 1: Column (2) is the total number of series in which a form owns patents (column 1) divided by the log of the size of the patent portfolio of that firm. This indicator can very between 0 (infinitive number of patents, once class) and 12,46 (one single patent in each of the 15 classes).

Note 2: ETSI and 3GPP use different coding for the classifications; for instance, ETSI deliverable TS 125.001 is equivalent to 3GPP deliverable TS 25.001. Although the translation for some deliverables is complex (especially the older GSM, that are also coded by 3GPP), the concordance for UMTS deliverables is rather straightforward.

Note 3: InterDigital notified patents for UMTS but indicated them to be relevant for the 3GPP TS41 series — a series for GSM Release 4, not UMTS. These declarations are counted as part of the similar series 21 patents, because InterDigital officially notified these patents for UMTS.

Table 7: Contrasting GSM and UMTS patent activity

	GSM	UMTS
Number of patent owners	23	72
Number of patents	140	1227
Estimated total royalty	0-13%	20%
Concentration of patents (CR4)	52.1%	72.4%
Concentration of patents (CR8)	72.9%	90.5%
Concentration of patents (HHI)	0.305	0.379
% patents by European firms	65.0%	62.9%
% patents by U.S. firms	26.4%	23.8%
% patents by Canadian firms	0.7%	1.5%
% patents by Japanese firms	7.9%	9.2%
% patents by Asian firms (excl. Japan)	0.0%	2.4%
% patents by firms from other countries	0.0%	0.2%

Table 8: Patent share by stakeholder category

Category	*Three largest IPR-holders in that category*	*Share of essential GSM patents*	*Share of essential UMTS patents*
Established supplier	GSM: Motorola, Nokia, Philips UMTS: Nokia, Ericsson, Motorola	55.7%	50.7%
New entrant	GSM: Alcatel, Nortel UMTS: Samsung, Asustek, Mitsubishi	10.7%	11.1%
Network operator	GSM: Telia, AT&T, NTT UMTS: France Telecom, Telia	20.0%	0.3%
Component supplier	GSM: Rockwell UMTS: Qualcomm, Philips, Voiceage	2.9%	22.6%
Technology developing and licensing firm	GSM: Innovatron, Lupa Finance UMTS: InterDgital, IPR Licensing, Salbu Research & Development	1.4%	14.3%
Adjacent technology developer	GSM: CP8 Transpac, Schlumberger UMTS: Sun Microsystems, Aepona, Canon	9.3%	0.6%
Other	GSM: (none) UMTS: ETRI, CCL/ITRI	0.0%	0.5%

Table 9: Strengths and weaknesses of IPR coordination mechanisms

		Improvement of				
Mechanism	*Timing of use*	*SC*	*TC*	*IC*	*HR*	*Major limitations*
Patent pools	Ex-post	++	++	+		IPR-owners with divergent business models are not likely to join. Pools can be anti-competitive towards non pool members.
Royalty free licensing	Ex-ante	+	+	++		Is unrealistic in industries where firms have heavily invested in R&D and patenting, and have made IPR an integral part of their business plans.
Non-assertion covenants	Ex-post	+	+	++		Only works when *all* initial IPR-owners agree to this approach.
IPR landscaping	Ex-ante	(+)	+	+		Reduces but does not eliminate risks, because firms are not required to disclose their licensing fees and conditions.
Ex-ante licensing terms	Ex-ante		+	+		Potentially reduces costs but limits standards bodies in their choice of technology. May delay standards development and provides no guarantee that all IPRs are cleared. May discourage participation.
Technology competition	Both			+	+	It may be difficult to build a competitive threat into a standard.
Regulatory intervention	Ex-post			(+)	+	Difficult to justify, and may decrease willingness of firms to invest in future R&D.
Royalty cap (voluntary or imposed)	Both			+		IPR-owners with diverging business models are not likely to agree or to feel bound. May discourage participation in standardization.

Figure 1: Timing of essential UMTS patents by leading manufacturers

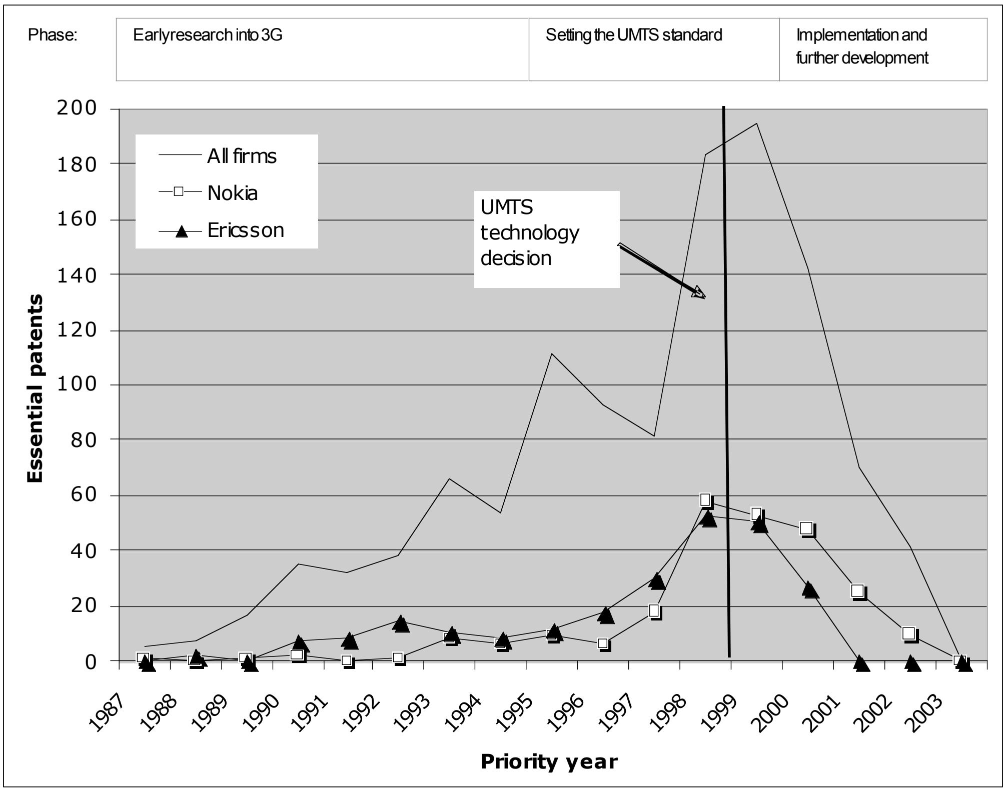

Figure 2: Timing of essential UMTS patents by leading IPR firms

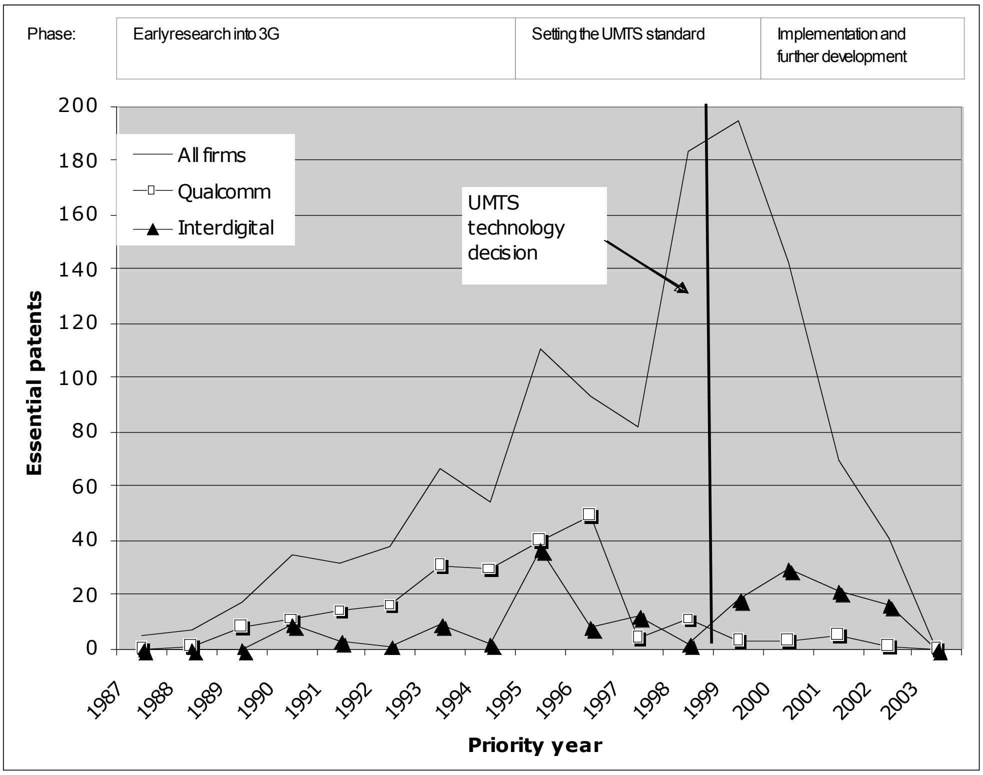

Figure 3: Essential patent portfolio size vs. firm telecommunications revenues