Review of Patents Declared as Essential to WCDMA Through October, 2008

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1 Executive Summary

Fairfield Resources has for more than six years, with support from Nokia and other wireless industry leaders, been studying the extent to which patents declared as essential to wireless standards actually are essential, as determined by a team of experienced wireless engineers. To date four such studies have been completed, two of which are in the public domain:

- Patents declared to ETSI[2] and ARIB[3] as essential to WCDMA Release 4 and CDMA2000 through December 31, 2003[4]
- Patents declared to ETSI as essential to GSM[5]
- Patents declared to ETSI and ARIB as essential to WCDMA Release 6 through February 1, 2005
- Patents declared to the Korean TTA[6] as essential to WCDMA through January 1, 2006

The present report extends through October, 2008 our reviews of patents declared as essential to one of the two third generation cellular technologies, WCDMA, Wideband Code Division Multiple Access, and also summarizes the judgment of our panel of expert engineers as to the essentiality of all patent families declared as essential to WCDMA in all our studies to date.

> **The primary report below covers patents and issued applications in 370 families issued or declared to ETSI or ARIB as essential to WCDMA Release 7 since our 2/1/2005 report, of which 146 (39%) were judged essential (E) or probably essential (E*). A total of 461 patents were reviewed in the present project including 91 additional family members that we found it necessary to review. These results are then combined with those of the three previous**

[1] This study was funded by Nokia which, however, was contractually bound to exert no influence on its content.
[2] ETSI: European Telecommunications Standards Institute
[3] ARIB: Association of Radio Industries and Businesses
[4] David J. Goodman and Robert A. Myers, *3G Cellular Standards and Patents*, IEEE Wireless2005 Proceedings, available at www.frlicense.com.
[5] David J. Goodman and Robert A. Myers *Analysis of Patents Declared as Essential to GSM as of June 6, 2007***,** (unpublished)., available at www.fr.license.com
[6] TTA: Telecommunications Technology Association

reports concerning WCDMA essential patents, resulting in a total of 1872 families studied of which 526 (28%) were judged essential.

One important new element of this latest study concerns Chinese patents. Our earlier studies were restricted to patent families in which there was at least one issued US, EP or JP patent. The last five years, however, have seen an explosion in the number of issued Chinese patents which were declared to ETSI as essential to WCDMA. Therefore, in this study we have also reviewed patent families in which the only issued patent is a Chinese patent. Fortunately, two members of our review team are native speakers of Chinese, so we did not have to contend with translation problems.

The following table summarizes the results of the present study where E means "judged essential", E* means judged "probably essential", N* means judged "probably not essential" and N means judged "not essential".

Table E-1 Summary of patent families evaluated

	Families Reviewed	Families Judged E/E*	Families Judged N/N*	Per Cent E/E*
European	135	55	80	41
United States	131	44	87	34
Japanese	6	3	3	50
Chinese	98	44	54	45
Total	**370**	**146**	**224**	**39**

The two most striking results are the large number of Chinese patents declared as essential and the 39% of all declared patents that our experts judged as essential, compared with 25% in our 2006 study and 28% overall.

As discussed in detail below, patents in the "network" category now dominate our study, as shown in the next two tables which present the top three technology categories. The percentages shown here refer to the total number of families reviewed. We refer to the present report in the following as the "2009 Study", since the following analysis was carried out in 2009.

Table E-2: Technical categories declared essential

Technical category	Patents declared Essential to WCDMA in 2009 Study		Patents declared Essential to WCDMA in 2006 Study		Total Patents Declared Essential including Korean TTA Study	
	number	percent	number	percent	number	percent
network	115	*31.1*	107	*7.6*	223	*12*
layer 2	60	*16.2*	96	*6.8*	184	*9.8*
radio resources	54	*14.6*	236	*16.7*	304	*16.2*

Table E-3: Technical categories judged essential
[percentages here refer to per cent of the number of patents judged essential]

Technical category	Patents Judged Essential to WCDMA in 2009 Study		Patents Judged Essential to WCDMA in 2006 Study		Total Patents Judged Essential including Korean TTA Study	
	number	percent	number	percent	number	percent
network	54	*37*	35	*9.8*	89	*16.9*
layer 2	29	*20*	43	*12*	82	*15.6*
radio resources	19	*13*	49	*13.7*	70	*13.3*

Although Ericsson, Nokia and Qualcomm continue to lead in the total number both of patents declared essential and patents judged essential, Huawei was the clear leader in both categories in the current study. Samsung, as a result of its many declarations to the TTA, not among the leaders in the present study, owns almost as many declared essential patents as Huawei, although our experts judged fewer Samsung patents essential.

Table E-4. Ownership of Declared IP

	2009 Study			2006 Study			Summary of All Studies incl. Korean TTA		
	Total	E/E*	N/N*	Total	E/E*	N/N*	Total	E/E*	N/N*
Huawei	111	51	60	-	-	-	**111**	**51**	**60**
Nokia	64	32	32	**198**	**103**	**95**	**262**	**135**	**127**
Ericsson	48	16	32	**254**	**83**	**171**	**302**	**99**	**203**
Qualcomm	36	9	27	**457**	**44**	**413**	**493**	**53**	**440**

Content of this report. Section 2 reviews the inherent conflict between standards and patents. Section 3 describes the evolution of cellular technology and the roles of two international Partnership Projects in standardizing third generation systems. Section 4 explains our definition of "essential" and where we find declarations of essentiality. Section 5 offers a concise review of WCDMA standards. Section 6 explains that after removing duplicate declarations (e.g., to two or more standards) and leaving only US, EP, JP and CN issued patents, the issued patents we have reviewed are clustered in 1872 "families". All the patents in a family cover substantially the same invention. Section 6 describes the process we have consistently followed to identify patents our experts judge to be essential. Section 7 presents a detailed discussion of the details of the concept of "patent family". In Section 8, we report the results of the current technical assessment of each patent family in order to estimate the number of inventions that are actually essential to WCDMA, presenting the data regarding patents declared as essential and patents judged as essential both by patentee and by technology category. These results are compared with the results for our earlier comprehensive review of patents declared as essential to WCDMA Release 6 and also with the sum of all our experts' opinions. Section 9 summarizes the results of our study of patents declared to the Korean TTA (Telecommunications Technology Association) as essential. In section 10 we discuss the significance and limitations of our results. Appendix A defines our technology categories.

In the interests of comprehensiveness, we have extracted considerable relevant material from our earlier reports for this summary report.

As further discussed below, any such analysis is intrinsically "preliminary", to the extent that other experts may disagree with ours. Further, intellectual property experts widely recognize that no patent opinion is final until and unless it has been litigated to a decision.

2 Standards and Patents

Information technology professionals are educated to seek the best technical solution to the tasks they address. However, the success or failure of these efforts, as indicated by the adoption of their contributions, depends on many factors besides the technical quality of the work. Two of these factors are technical standards and intellectual property rights (IPR) to technology that complements or competes with the proposed solutions. Standards can accelerate technology proliferation; they can also be barriers to innovation[7]. Governments issue patents to reward innovation and stimulate technology creation. However, distortions in the patent system can stifle creativity and block deployment of the best technology[8]. The problem is especially acute when "… a user needs access to multiple patented inputs to create a single useful product." In these circumstances the patent system can retard, rather than encourage, innovation[9].

An article in *IEEE Spectrum* documents the tug of war between patent ownership and formulation of information technology standards[10]. Open (as opposed to proprietary) standards promote positive externalities and encourage widespread technology deployment. On the other hand, patents, by their nature as exclusionary monopolies, restrict technology deployment in order to encourage technology creation. Organizations that formulate open standards would like to exclude patented technology from the standards. If that is not possible, as is often the case, they prefer that patent owners grant free licenses to implement their patents in products that conform to the standards. In practice, however, information technology standards organizations are populated by representatives of companies that aim to profit from ownership of their IPR.

From the point of view of the public interest, standards organizations have to compromise between the goal of unimpeded access to the standard and the possibility that "excluding a patented invention from a standard can unreasonably restrain trade by … excluding a technically advanced product from the market"[11]. To reconcile the contradiction between

[7] P. Passal, Why the best doesn't always win, New York Times Magazine, May 5, 1996, pp 20 - 21.

[8] A. B. Jaffe and J. Lerner, Patent Prescription, A Radical Cure for the Ailing U.S. Patent System, IEEE Spectrum, Vol. 41, No. 12, December 2004, pp 38-43.

[9] M.A. Heller and R. S. Eisenberg, Can Patents Deter Innovation? The Anticommons in Biomedical Research, Science, Vol 280, May 1, 1998, pp 698-701.

[10] S. J. Frank, Can you patent an industry standard?, IEEE Spectrum**,** Vol. 39, No. 3, March 2002, pp. 14 – 15

[11] A. A. Marasco, "ANSI Reporter", Autumn/Winter 2003.

open standards and patent ownership, standards organizations encourage members to disclose "essential" patents and to agree to license the patents to all interested parties on "fair, reasonable, and non-discriminatory" terms. The difficulties inherent in applying this criterion in the real world are well summarized in a paper by a senior Nokia executive.[12]

3 Evolution of cellular technology and standards

Cellular telecommunications dates from the 1970s, when the first experimental systems demonstrated the technical feasibility of a radically new approach to telephony. The first commercial systems appeared in the early 1980s and since then technical progress has been measured in "generations". First generation technology relied on analog frequency modulation to transmit voice signals. Second generation systems, introduced in the 1990s, transmit speech in digital format. To promote network security and enable international roaming, they employ standardized signaling protocols for communication among elements of the infrastructure of base stations, mobile switching centers and databases. There are two broad categories of second generation systems, distinguished by their approaches to multiplexing and multiple access of radio signals. Some systems employ time division (TDMA) and others employ code division (CDMA). There are two standards for signaling in the core network: the mobile applications part of the Global System for Mobile Communications (GSM) and Interim Standard 41, published by the Telecommunications Industry Association. In 2008 the ITU estimated that there would be 4 billion cellular subscribers worldwide, with more than 600 million in China by the end of that year. Almost 400 million are estimated to use WCDMA.

In recent years, GSM network operators have introduced two major upgrades to the original radio transmission technology. GPRS is a packet data overlay to the original circuit-switched technology of GSM. EDGE introduces 8-level phase shift keying modulation alongside Gaussian minimum shift keying, the original binary modulation technique of GSM. Both EDGE and GPRS are often referred to as "2.5G" technologies.

In 2005, many network operators began migrating to third generation (3G) technologies, with standardization guided by two "Third Generation Partnership Projects", 3GPP[13], and 3GPP2[14]. The original Partnership Project, 3GPP, is concerned with descendents of GSM. The technology standardized by 3GPP is often referred to as WCDMA (wideband code division multiple access). The other Project, 3GPP2, is concerned with advanced versions of the original CDMA cellular system. The technology standardized by 3GPP2 is often referred to as CDMA2000.

The Partnership Project members are regional and national standards organizations and "individual members," companies affiliated with one or more of the constituent standards organizations. Table 1 lists the standards organizations - based in Europe, the United

[12] Timo Ruikka, "*FRAND" Undertakings in Standardization — A Business Perspective*, Les Nouvelles, September, 2008.
[13] www.3gpp.org
[14] www.3gpp2.org

States, Japan, China, and Korea – in the two Partnership Projects. There are currently 369 individual members of 3GPP.

Table 1: Organizational Members of the Partnership Projects

Organizational Member	Nationality	Affiliation
Association of Radio Industries and Businesses	Japan	3GPP and 3GPP2
Alliance for Telecommunication Industry Solutions	United States	3GPP
China Communications Standards Association	China	3GPP and 3GPP2
European Telecommunication Standards Institute	Europe	3GPP
Telecommunications Industry Association	North America	3GPP2
Telecommunications Technology Association	Korea	3GPP and 3GPP2
The Telecommunication Technology Committee	Japan	3GPP and 3GPP2

Third generation cellular standards. Among the many types of standards, the ones that specify the details of telecommunications equipment are in the category of "compatibility specifications"[15]. Their purpose is to insure that different types of conforming equipment (for example cellular telephones and base stations) will operate correctly when they interact. The technologies covered by 3G cellular standards reside in three domains: core network, radio access network, and operations[16]. At the beginning of 2009, the current 3GPP specifications were components of Releases 7 and 8.user equipment. These categories are only partly reflected in the organization of the two standardization projects: 3GPP and 3GPP2. Both projects have assigned the formulation of specifications to Technical Specification Groups (TSG). However, the definitions of the TSGs are different in the two projects. The TSGs in 3GPP are concerned with (a) core network, (b) radio access network, (c) terminals, and (d) service and systems aspects[17]. In 3GPP2, the TSGs are (a) access network interfaces, (b) CDMA2000, (c) services and systems aspects, and (d) intersystem

[15] D. J. Goodman, *Standards for Personal Communications in Europe and the United States,* Program on Information Policy Research, Harvard University, 1998. http://pirp.harvard.edu/pubs_pdf/goodman/goodman-p98-1.pdf

[16] http://www.3gpp2.org/Public_html/Misc/CommitteesHome.cfm

[17] http://www.3gpp.org/TB/home.htm

4 Essential Patents

The Partnership Projects and their constituent standards organizations encourage individual members to "declare" patents and patent applications that they believe are "essential" to implementing third generation cellular standards. The official definition of essential is formulated in negative terminology:

> *"ESSENTIAL" as applied to IPR means that it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art generally available at the time of standardization, to make, sell, lease, otherwise dispose of, repair, use or operate EQUIPMENT or METHODS which comply with a STANDARD without infringing that IPR*[18].

Lists of patents declared essential to WCDMA appear at the web site of the European Telecommunications Standards Institute (ETSI)[19]. Lists of patents declared essential to CDMA2000 and WCDMA appear at the web sites of the Association of Radio Industries and Businesses (ARIB)[20], The Telecommunication Technology Committee (TTC)[21], and the Telecommunications Technology Association (TTA).[22] ARIB and TTC are Japanese standards organizations, while the TTA is a Korean organization. All of these sites are accessible in English. As of November, 2008, we have identified more than 10,000 patents and then-pending applications declared as essential to WCDMA

The most recent release of the WCDMA standards is Release 7.0, and our expert team has analyzed all patents issued since January 1, 2006 for essentiality to this standard. For budgetary reasons, we did not re-review any of the patents previously reviewed against Release 6, but our professional judgment is that there would be a very small number of changes in our experts' opinions.

With the widespread deployment of 3G wireless systems, the engineering community has turned its attention to fourth generation technology. Currently there are two leading contenders. One, based on the use of orthogonal frequency division in the radio access network, is known as LTE, for long term extension. The core network aspects of the related 4G systems are known as SAE, system architecture extension. A competing "4G" technology, already being deployed in some areas, is known as Wi-Max. The standards for LTE are being developed as Release 8.0 of the WCDMA standards.

Third generation cellular standards. Among the many types of standards, the ones that specify the details of telecommunications equipment are in the category of "compatibility

[18] "ETSI IPR Policy", Nov. 22, 2000. http://www.etsi.org/legal/documents/ETSI_IPRPolicy.pdf
[19] www.etsi.org
[20] www.arib.or.jp
[21] www.ttc.or.jp
[22] www.tta.or.kr

specifications”23. Their purpose is to insure that different types of conforming equipment (for example cellular telephones and base stations) will operate correctly when they interact. The technologies covered by 3G cellular standards reside in three domains: core network, radio access network, and operations24. At the beginning of 2009, the current 3GPP specifications were components of Releases 7 and 8.user equipment. These categories are only partly reflected in the organization of the two standardization projects: 3GPP and 3GPP2. Both projects have assigned the formulation of specifications to Technical Specification Groups (TSG). However, the definitions of the TSGs are different in the two projects. The TSGs in 3GPP are concerned with (a) core network, (b) radio access network, (c) terminals, and (d) service and systems aspects25. In 3GPP2, the TSGs are (a) access network interfaces, (b) CDMA2000, (c) services and systems aspects, and (d) intersystem

5 Declared patents

Our sources for patents and patent applications declared essential to WCDMA technology are the web sites of four standards organizations. ETSI lists declarations of patents declared essential to 3GPP, as well as declarations of patents declared essential to other technologies standardized by ETSI[26] including GSM. The web sites of the Japanese standards organizations ARIB[27] and TTC[28] contain information about patents and patent applications declared essential to both third generation technologies as does the web site for the Korean Telecommunications Technology Association (TTA)[29]. The ARIB notation for 3GPP standards is T63. The TTC notation is 3GA. For 3GPP2, the respective notations are T64 (ARIB) and 3GB (TTC). Finally, the TTA web site lists patents declared as essential to WCDMA. In the United States, the web site of the Telecommunications Industry Association contains statements by companies that have agreed to license essential patents on a non-discriminatory basis[30], but it does not contain lists of individual patents and patent applications.

The patent families in this 2009 Fairfield study were declared essential to a variety of communications systems standardized by 3GPP. More than 75% of the patents were declared essential to UMTS, the third generation European cellular system based on WCDMA voice transmission. Another 10% of the patents were declared essential only to “3GPP”, without naming a specific system. Other patents were declared essential to

[23] D. J. Goodman, *Standards for Personal Communications in Europe and the United States,* Program on Information Policy Research, Harvard University, 1998.
http://pirp.harvard.edu/pubs_pdf/goodman/goodman-p98-1.pdf
[24] http://www.3gpp2.org/Public_html/Misc/CommitteesHome.cfm
[25] http://www.3gpp.org/TB/home.htm
[26] www.etsi.org
[27] www.arib.or.jp
[28] www.ttc.or.jp
[29] www.tta.or.kr
[30] http://www.tiaonline.org/

second generation technologies, GSM, GPRS, GERAN, and to "fourth generation" LTE[31].

Our study of WCDMA intellectual property is based on the ETSI, ARIB and TTA lists containing over 15,000 patents and applications declared as essential to WCDMA and related standards as of October, 2008. We have now analyzed the patents and patent applications declared essential to WCDMA in order to cluster patents and applications into distinct "patent families". The members of a family are patents obtained in different countries for a single invention. We determined that for WCDMA, there now 1872 patent families with US, EP, JP or CN patents issued prior to November 1, 2008.

It is important to remember that we examined only patents explicitly declared as essential to 3GPP standards. Many companies, as a matter of policy, do not participate in setting standards nor do they declare any of their patents to be essential and thus agree to license them for a reasonable and non-discriminatory royalty. It is also important to note that the backward compatibility aspects of 3G standards means that patents declared as essential to an earlier standard such as GSM, TDMA or EDGE may also be essential to 3GPP.

After clustering the patents into families, we chose one patent from each family for further analysis. To select a patent declared essential to WCDMA, we first looked for a patent issued by the European Patent Office. If there was no European patent in the family, we selected a United States patent if one was present. Our next choice was a Japanese patent and the final choice was a Chinese patent. We reviewed only three families with no European, United States, Japanese or Chinese patent. For those inventions, we analyzed a German patent, a British patent, and a Swedish patent.

6 Process Followed in the Fairfield Study

The lists of declared patents and patent applications compiled by ETSI, ARIB, TTC and TTA in aggregate contain on the order of 20,000 distinct entries. Each patent or application is published by either a national patent issuing office or the European Patent Office. However, the number of inventions is considerably less than 20,000 mainly because it is customary for inventors to patent a single invention in many different countries.

A major task in our study was to analyze the ETSI, ARIB, TTC and TTA databases in order to select patents to evaluate. In our current study, we limited this analysis to patents declared to ETSI, as we have found that nearly all of the patents declared to the other organizations have also been declared to ETSI. The impact of any families we missed on our results we judge to be *de minimus*. Many of the patents declared as essential to one of the 3G systems are declared to two or even all three standards bodies, so it was first necessary to remove duplicates. Among the unique patents and patent applications, the first selection criterion was to evaluate only issued patents. To do so, it was necessary to examine each declared application to determine whether the application eventually

[31] We hope to address the fourth generation patents in a future study.

resulted in an issued patent. The study evaluated patents issued and declared as essential to the extent this information is available[32] on or before November 1, 2008. We have also deleted from our final results any patents which expired during the course of our study as well as any patents judged essential by our experts which had been revoked or had otherwise lapsed.

To make the steps involved clearer, we provide the following high level picture of the process flow Fairfield followed in this study.

1. Establish Criteria and Priority for Patents to Review
    - EP/US/JP/CN/Other major economy
    - Active
    - Issued before 11-1-2008
    - Most recently filed family member

2. Find Declared Patents and Standards on Standards Organization Sites (All have English language links)
    - http://www.etsi.org/WebSite/homepage.aspx [European Technical Standards Institute]
    - http://www.arib.or.jp/ [Association of Radio Industries and Businesses]
    - http://www.ttc.or.jp/ [Telecommunications Technology Committee]
    - http://www.3gpp.org [3GPP Partnership Project]
    - http://www.tta.or.kr [Telecommunications Technology Association]

3, Search On-Line Patent Sites for Family Data
    - www.delphion.com
    - www.espacenet.com
    - www.uspto.gov/pair
    - http://218.240.13.210/sipo_EN/search/tabSearch.do?method=init

4. Find All Issued Declared Patent Applications Meeting Criteria

5. Identify and select for initial review most recently filed family member

6. Remove Chaff
    - Duplicates
    - Expired or abandoned patents
    - Other family members
    - Other economies

7. Obtain Translations of JP Patents

8. Assign Patents to Appropriate Technology Category

[32] ARIB does not make the date of declaration available.

- One category per patent

9. Review List for Obviously Non-essential Patents
    - Categorize them as "not essential"

10. Distribute Remaining Patents to Experts for Review[33]

11. Edit Reviews for Consistency.[34]
    - Determine expiration date of essential patents

For initially reviewed ***non-essential*** patents
12. Find and Review All Issued EP and US Family Members in that order for Essentiality, halting if/when a family member has been judged as essential[35].
    - Continuations
    - Divisionals
    - Other patents listed on cover page, i.e. "related patents"

13. Analyze Results and Prepare Report

7 Patent Families

Although widely used, the term "patent family" is not an accepted "term of the [patent] art" and is thus subject to misinterpretation due to different parties using it differently. Since an understanding of the concept is basic to our process, we provide the following overview of the topic, with links to related web sites.

There are four patent databases for identifying patent families, and each deals with these families differently.

- World Patent Index (WPI) - Derwent Information Ltd.
- INPADOC - EPIDOS, The European Patent Office
- EDOC - INPI, The French Patent & Trademark Office
- CAS - Chemical Abstracts Service

None of these databases provide a complete patent family. Since there are over 170 countries which grant patent protection and INPADOC, which covers the most countries, only covers 60 countries, these databases do not provide a comprehensive survey of patent protection. Also, these databases do not necessarily provide complete coverage for the countries they do cover."[http://www.piug.org/patfam.php]."

[33] See below for a description of our experts' qualifications.
[34] Apart from polishing grammar and spelling, assuring that the rationale language is consistent with the reviewer's assessment and removing irrelevant comments.
[35] In our 2006 study we reviewed all family members if the patent initially reviewed was judged not essential.

In our study, the operational definition we used is either the field "patent family" accessed on the www.delphion.com web site or the INPADOC family data provided by www.espacenet.com. Both Delphion and Espacenet obtain this data from INPADOC [International Patent Documentation Center], maintained by the European Patent Office. Since our study was limited to major economies, the US, the EP, and Japan in particular, the differences between the patent family data in the four databases was not judged to be material.

There are essentially four different kinds of members of a patent family.

Counterpart patents and applications. Since a patent is only enforceable in the jurisdiction in which it has been issued, inventors often file for patents in multiple countries. This is particularly common in fields like telecommunications where the invention may be practiced globally. In order to obtain coverage in a country, the initial patent application, including the claims, must be translated into the local language and the application must be examined and approved by the national patent office. Even though all counterpart patents ("family members") are based on the same invention and the specifications differ only in translation nuances, negotiation with examiners and the process of translation may lead to significant differences between the different foreign counterparts. In our study, since both United States patents and claims for European patents are written in English, there is no translation issue[36]. We do not believe there is a significant risk from differences in claim language resulting from the examination process. Since we reviewed Japanese patents in those cases where there was no US or EP counterpart, there remains the possibility inherent in all translations that the professional Japanese-English translations of the claims we secured might have been misunderstood by our reviewers. Since our reviewers reviewed all 118 JP patents without any reported objection, we believe that this did not have a significant effect on our overall results[37].

Continuations and continuations-in-part. "A *continuation* is a second application for the same invention claimed in a prior nonprovisional application and filed before the original prior application becomes abandoned or patented. The disclosure presented in the continuation must be the same as that of the original application; i.e., the continuation should not include anything which would constitute new matter if inserted in the original application. A *continuation-in-part* is an application filed during the lifetime of an earlier nonprovisional application, repeating some substantial portion or all of the earlier nonprovisional application and *adding matter not disclosed* in the said earlier nonprovisional application"[38]. Continuations and continuations-in-part are not permitted by the EPO or the JPO. United States inventors have the ability to "continue" a patent application by filing a new patent application which claims priority from the initial filing date but which has new claims which must, however, be based on the original specification which is ordinarily not changed [possibly except for typographical

[36] Claims are normally provided in English, French and German, although the specification (and drawings) may be only in the original language.
[37] The percentage of 118 JP patents judged essential, 18%, was close enough to the rate for all other patents to further suggest that our reviewers were not unduly troubled by the translations.
[38] US Manual of Patent Examination Procedure

corrections]. The continuation application's claims must be examined and approved as would an original patent application. A continuation may itself be continued. Inventors may file for a continuation to in effect obtain a further examination, (e.g., when they are unable to persuade the examiner regarding their position) or to adapt the initial claims to cover new products, services, or technologies. A continuation-in-part may also provide a mechanism for extending the life of a patent.

Divisional patents. **"**A later application for an independent or distinct invention, carved out of a pending application and disclosing and claiming only subject matter disclosed in the earlier or parent application, is known as a divisional application or "division." A divisional application is often filed as a result of a restriction requirement made by the examiner."[39] A common reason for such restrictions is the case in which the initial patent application is judged by the examiner to cover more than a single discrete invention. As in the case of continuations, the specification ["disclosure"] for all of the divisional patents is usually unchanged. Since divisional patent applications need not be contemporaneous with the original application, such applications offer another means to "tune" a patent's claims to changing circumstances. Divisional patents are permitted by the EPO, and provide a kind of alternative to continuations where this is allowed by the patent office. Divisional applications are also available in Japan, for example, "when (a) the claims are rejected due to lack of unity of invention, (b) a part of the claims is rejected, (c) a desired amendment cannot be made due to restriction on amendment or (d) a pending application (insurance) is needed."[40]

Related patents. **"**Related patent applications are those filed after an initial original application is filed but before it is issued as a patent and that involve similar or related technologies. For example, an inventor may come up with an improvement to technology disclosed in an earlier filed application. Instead of filing a new patent application for the improvement, the patent laws allow the inventor to supplement the earlier application by filing a continuation-in-part (CIP). A CIP is just one of the several types of related applications."[41]

The four different sources of patent family information do not follow a single procedure for linking family members. One linkage would be all patents claiming the same priority date. Another would be a series of patents with the same title and inventors but different priority dates. Yet another would be patents with the same title but different inventorship, as might be the case in a divisional patent. Different primary sources (INPADOC, EDOC) might not agree on all the "related" members of a family. In INPADOC, priority numbers and application numbers are used for establishing family links. The United States Patent and Trademark Office does not appear to have a hard and fast rule about what constitutes a "related patent" and a patent applicant may state in his application that it is related to other pending or issued patents. As a practical matter, we do not believe

[39] US Manual of Patent Examination Procedure
[40] http://www.taniabe.co.jp/e/infomation/main-patent023.html
[41] David Radack, *Understanding "Related" US Patent Applications*
http://www.tms.org/pubs/journals/JOM/matters/matters-0406.html

that choosing a different "related" member of a family from the one we chose to review would have a significant effect on our findings. See also, the discussion above regarding continuations and continuations-in-part that we reviewed.

Our motivation for seeking out the most recently filed member of a series of continuations is the recognition that a continuation application provides the inventor(s) an opportunity to "tune" the claims to the latest version of a standard. However, in response to questions about the validity of this premise, we asked our reviewers to review *every* forward and backward continuation and division of and related patents declared as essential to WCDMA which were initially judged "not essential". Out of 147 such families, eleven additional families were judged as essential.

Caveat. Since we eventually examine every patent in a family, our process provides assurance that if any family member is essential we will review it. A contributor to possible errors arises from the fact that in the definition of family member followed by INPADOC the first consideration is priority date, followed by IPC code and assignee. Since many major patentees batch their patent applications, this can result in the appearance on the Delphion[42] or Espacenet[43] web sites of spurious family members. More troubling is the appearance of ostensible family members which are assigned to different entities. We have removed all such errors we found, but the "family member" field in our data is still subject to possible undiscovered anomalies. The most confusing aspect of our use of "patent family" data occurs with certain families – fortunately very infrequently – in which the different members are apparently technologically unrelated except that they arise from a common priority application which has been continued and divided for years. Our review process is almost guaranteed to find an essential patent in such a family, but other "family" members covering different inventions may not be found. Since there have been only a handful of such patents, we believe they have a negligible effect on the validity of our results. There was one family with 32 members in the 2009 study. No other family had more than 11 members.

8 Results of the 2009 Study

8.1 Summary

The results of the selection process are summarized in Table 3, which shows the number of patent families selected in the four jurisdictions and our experts' opinions.

[42] www.delphion.com
[43] www.espacenet.com

Table 1 Summary of patent families evaluated in 2009 study

	Families Reviewed	Families Judged E/E*	Families Judged N/N*	Per Cent E/E*
European	135	55	80	41
United States	131	44	87	34
Japanese	6	3	3	50
Chinese	98	44	54	45
Total	**370**	**146**	**224**	**39**

8.2 Patent categories

As in all our previous studies, while examining patents from each patent family we sorted the patents into 17 technical categories, covering key aspects of CDMA cellular communications. Eight examples are (a) radio signals, covering CDMA fundamentals (including spreading codes, physical channels, and modulation) (b) radio resources management (including power and rate control), (c) location management (including location determination and mobility management), (d) layer 2 (including media access control, error detection, and retransmission), (e) source coding, channel coding, (f) core network operations, (g) call management, and (h) synchronization. Table 2 shows the categories and the number of WCDMA patents in each category.

Table 2: Technical categories declared essential

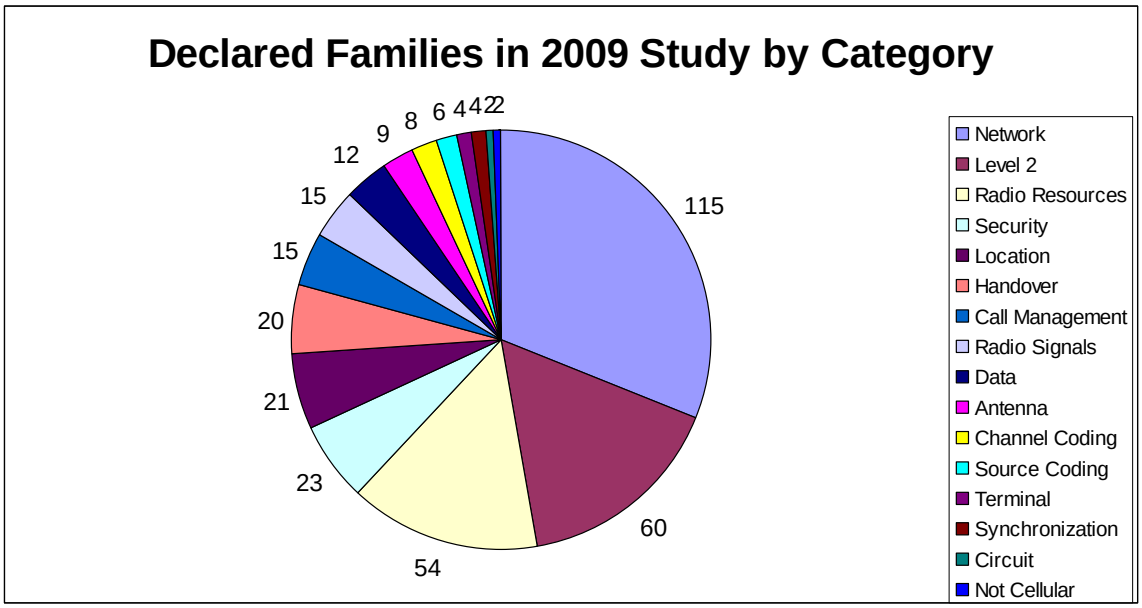
Technical Category	Patents declared Essential to WCDMA in 2009 Study		Patents declared Essential to WCDMA in 2006 Study		Total Patents Declared Essential including Korean TTA Study	
	number	**percent**	**number**	**percent**	**number**	**percent**
Total	370		1417		1872	
network	115	*31.1*	107	*7.6*	223	*12*
layer 2	60	*16.2*	96	*6.8*	184	*9.8*
radio resources	54	*14.6*	236	*16.7*	304	*16.2*
security	23	*6.2*	44	*3.1*	67	*3.6*
location	21	*5.7*	68	*4.8*	90	*4.8*
handover	20	*5.4*	135	*9.5*	155	*8.3*
call management	15	*4.*	71	*5.*	86	*4.6*
radio signals	15	*4.*	179	*12.6*	205	*11*
data	12	*3.2*	48	*3.4*	65	*3.5*
antenna	9	*2.4*	43	*3.0*	52	*2.8*
channel coding	8	*2.1*	88	*6.2*	112	*6*
source coding	6	*1.6*	111	*7.8*	117	*6.2*
synchronization	4	*1.1*	80	*5.6*	86	*4.6*
terminal	4	*1.1*	30	*2.1*	35	*1.9*
electronic circuits	2	*0.5*	74	*5.2*	76	*4.1*
fax	0	-	3	*.2*	3	*0*
tdma	0	-	4	*.3*	4	*0*

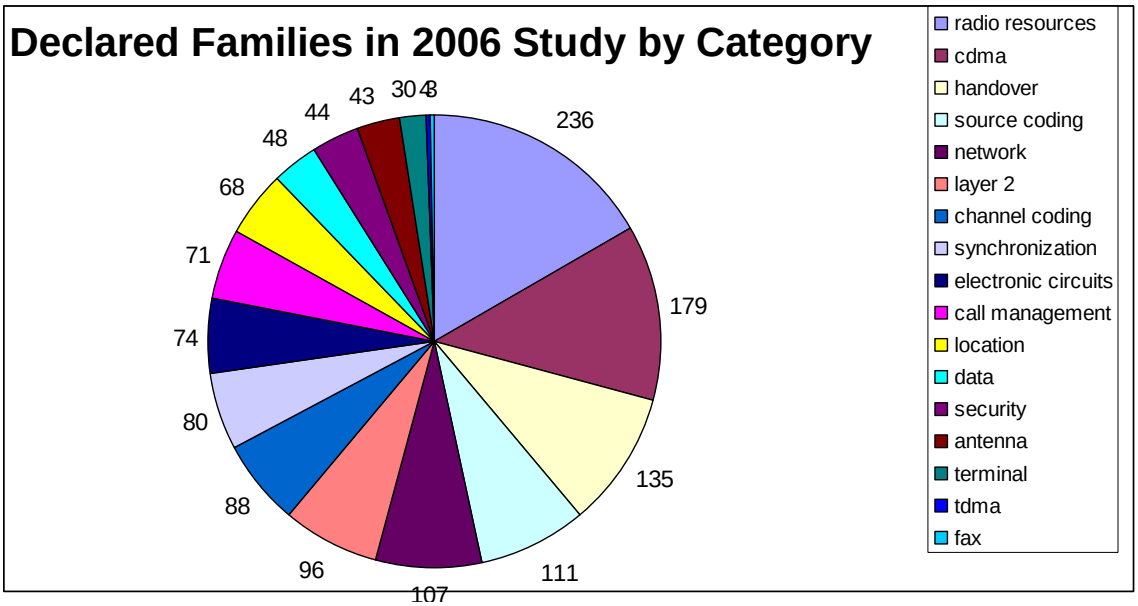
Table 3: Technical categories judged essential

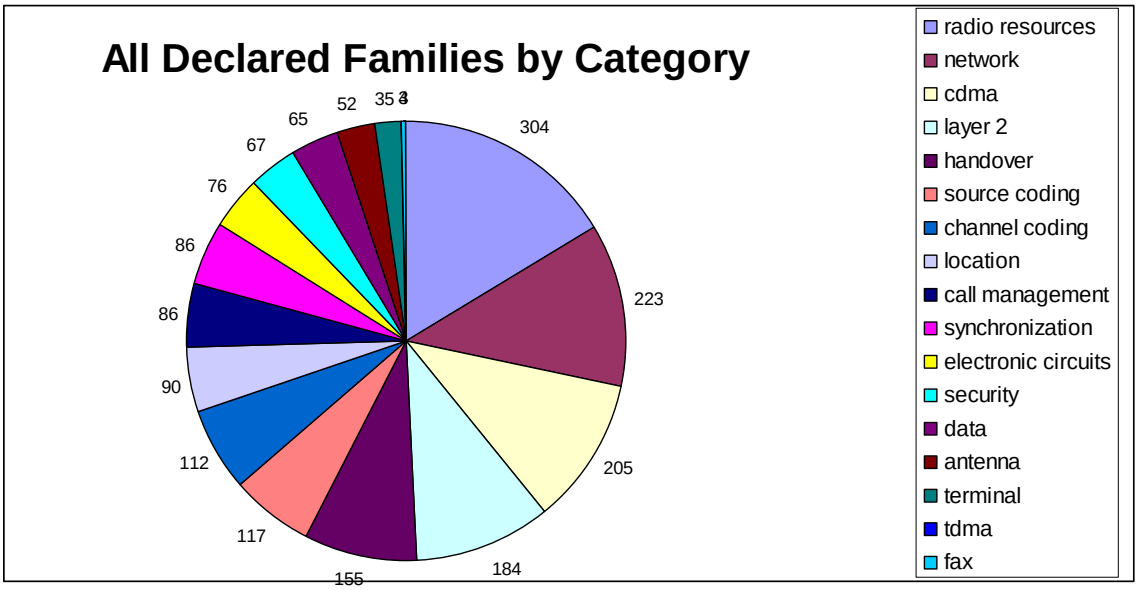
Technical category	Patents Judged Essential to WCDMA in 2009 Study		Patents Judged Essential to WCDMA in 2006 Study		Total Patents Judged Essential including Korean TTA Study	
	number	percent	number	percent	number	percent
network	54	*37*	35	*9.8*	89	*16.9*
layer 2	29	*20*	43	*12*	82	*15.6*
radio resources	19	*13*	49	*13.7*	70	*13.3*
security	9	*6.2*	15	*4.2*	24	*4.6*
location	8	*5.5*	25	*7*	34	*6.5*
data	7	*4.8*	14	*3.9*	24	*4.6*
handover	6	*4.1*	39	*10.9*	45	*8.6*
call management	4	*2.7*	29	*8.1*	33	*6.3*
radio signals	4	*2.7*	35	*9.8*	41	*7.8*
source coding	3	*2*	32	*8.9*	35	*6.7*
antenna	1	*.7*	6	*1.7*	7	*1.3*
channel coding	1	*.7*	14	*3.9*	19	*3.6*
synchronization	1	*.7*	16	*4.5*	18	*3.4*
electronic circuits	0	*0*	3	*.8*	3	*.6*
fax	0	*0*	2	*.6*	2	*.4*
tdma	0	*0*	0	*0*	0	*0*
terminal	0	*0*	1	*.3*	1	*.2*
Total	146		358		526	

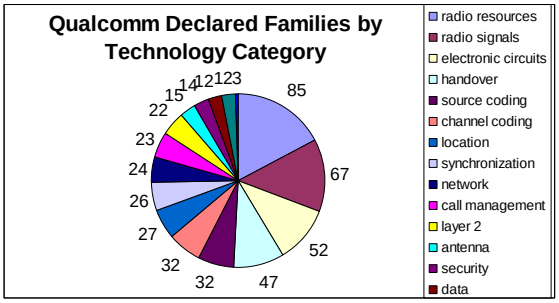
Table 4. Total Declared Patent Families by Category for Leading Patentees

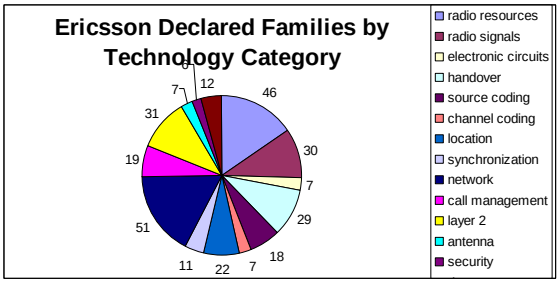
	Huawei		Ericsson		Nokia		Qualcomm		Samsung	
	Decl'd	E/E*	Decl'd	E/E*	Decl'd	E/E*	Decl'd	E/E*	Decl'd	E/E*
radio resources	7	4	46	10	33	14	85	10	20	4
radio signals	2		30	10	9	2	67	8	18	1
electronic circuits			7				52		2	
handover	4		29	9	30	14	47	10	1	1
source coding			18	7	20	12	32	4		
channel coding			7		4	2	32	1	35	5
location	4	2	22	14	19	8	27	3		
synch			11	4	5	2	26		5	1
network	61	30	51	16	46	25	24	3		
call mgmt	4	2	19	6	29	16	23	4		
layer 2	10	5	31	16	27	17	22	6	17	3
antenna			7		4	3	15		3	
security	15	6	6	3	14	11	14			
data	2	2	12	4	16	8	12	2		
terminal						1	12			
fax							3	2		

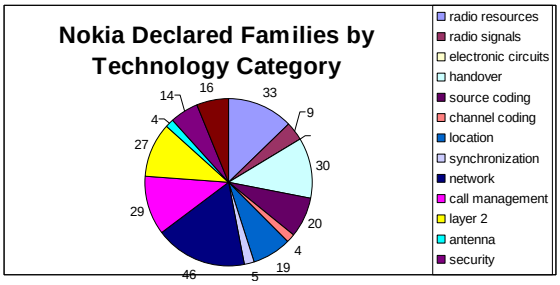


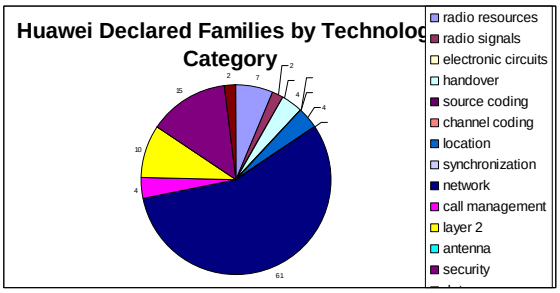


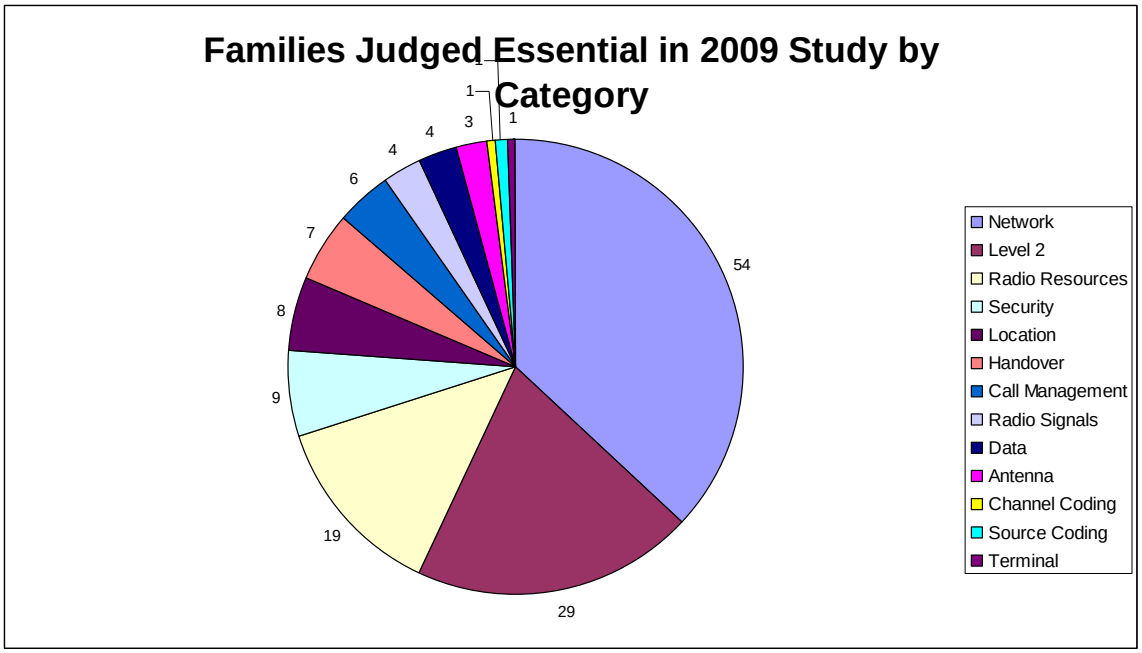


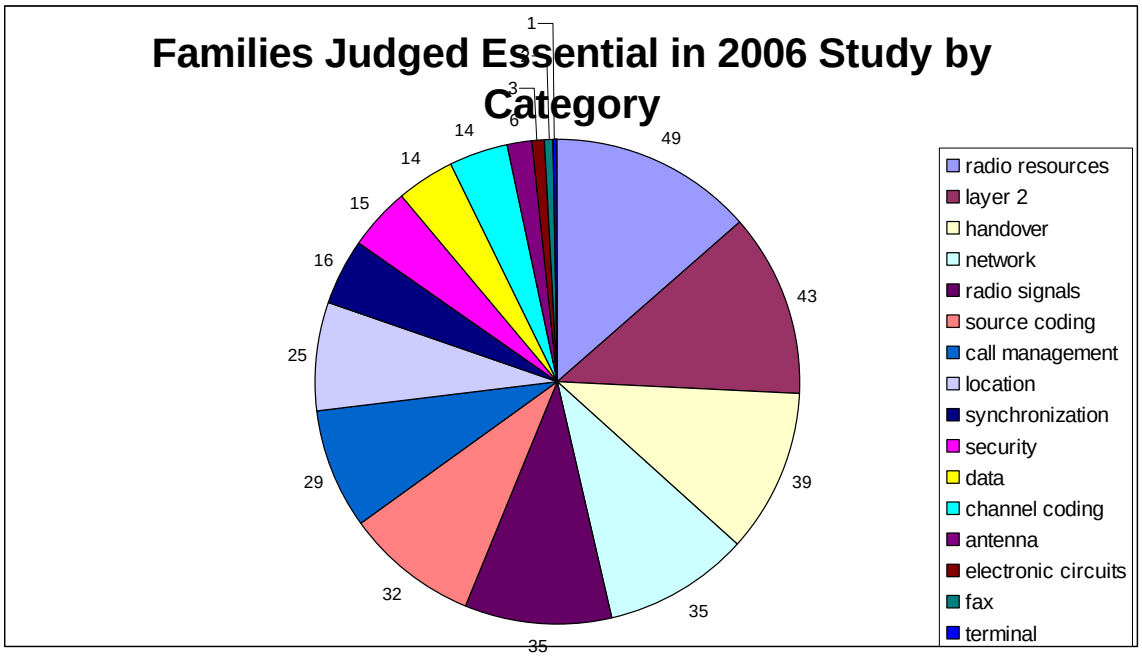


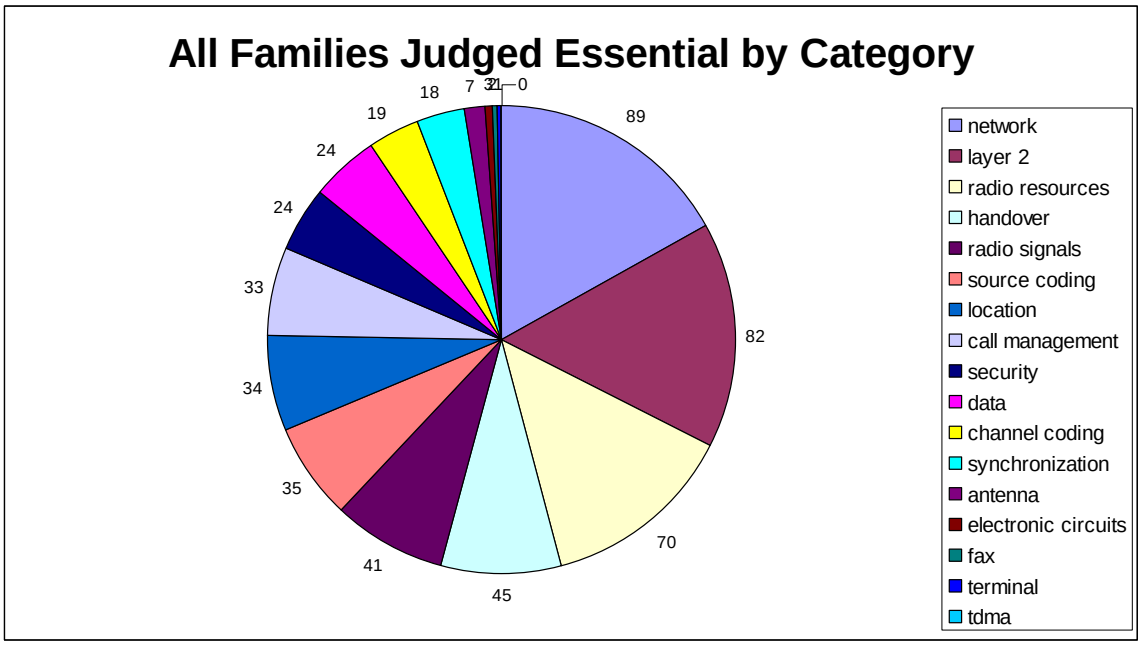


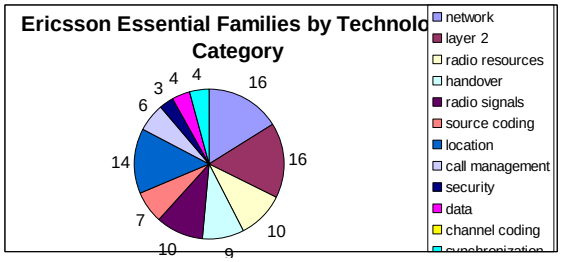


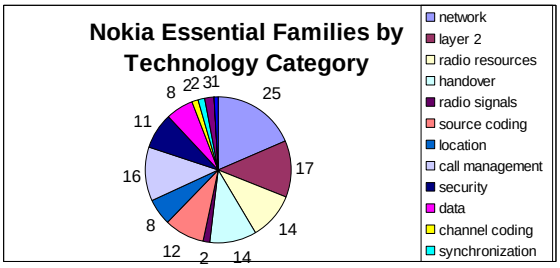


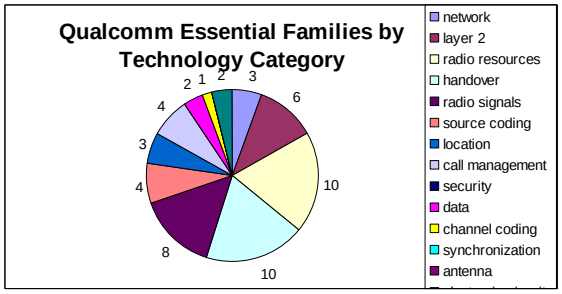


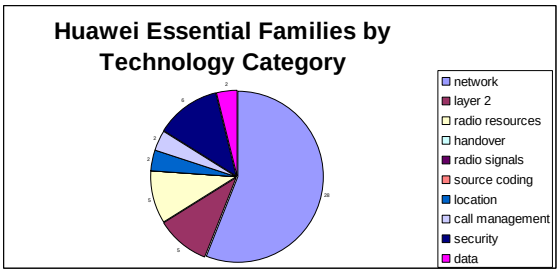












8.3 Patent Ownership

In addition to the names of inventors, it is customary for a patent to state that the rights to the patent are “assigned” to a certain organization, usually the employer of the inventors. In this latest study the patents are assigned to 26 different companies, of which four

companies own the rights to almost three quarters of the patents declared essential to WCDMA: Huawei (replacing Motorola from the earlier study), Nokia, Ericsson and Qualcomm. Table 6 shows the distribution of patent ownership for patents declared essential to 3GPP standards, while Table 7 shows the percentage of declared patents which our experts judged to be essential. It is interesting to note that Qualcomm and Ericsson, with slightly less than half the total number of families reviewed, had fewer than 20% of their families judged E/E*. 11% of the 493 families declared essential by Qualcomm were judged essential.

Table 5. Ownership of Declared IP

	2009 Study			2006 Study			Summary of All Studies incl. Korean TTA		
	Total	E/E*	N/N*	Total	E/E*	N/N*	Total	E/E*	N/N*
Huawei	111	51	60	-	-	-	111	51	60
Nokia	64	32	32	198	103	95	262	135	127
Ericsson	48	16	32	254	83	171	302	99	203
Qualcomm	36	9	27	457	44	413	493	53	440
Nortel	20	1	19	17	4	13	37	14	23
Samsung	13	4	9	41	4	37	103	15	88
Siemens	11	8	3	33	18	15	44	26	18
Matsushita	8	2	6	45	10	35	53	12	41
Apple	8	1	7				8	1	7
Alcatel	7	5	2	19	6	13	26	11	15
NTT Docomo	6	3	3	47	10	37	53	13	40
Motorola	5	4	1	42	11	31	47	15	32
NEC	5	3	2	33	7	26	38	10	28
Research In Motion	5	1	4				5	1	4
ASUSTEK	4	2	2	12	8	4	16	6	10
British Telecommunications	4	2	2				4	2	2
Fujitsu	3	0	3	22	1	21	25	1	24
Interdigital	2	0	2	40	15	25	42	15	27
Philips	2	0	2	24	4	20	26	4	22
Innovative Sonic	2	1	1				2	1	1
Hitachi	1	0	1	15	4	11	16	11	5
Dilithium Networks	1	0	1				1	0	1
IPWireless	1	0	1				1	0	1
TI	1	0	1	7	3	4	8	3	5
ETRI	1	1	0	2	0	2	3	1	2
Broadcom	1	0	1	1	0	1	2	0	2
Mitsubishi	-			29	11	18	29	11	18
Toshiba	-			18	1	17	18	1	17

NTT	-	8	2	6	8	2	6
Cellco	-	6	0	6	6	0	6
Kokusai Electric	-	5	0	5	5	0	5
Oki	-	5	1	4	5	1	4
France Telecomm	-	4	1	3	4	1	3
Saibu	-	4	0	4	4	0	4
Telia AB	-	4	0	4	4	0	4
KDD	-	3	0	3	3	0	3
Raytheon	-	3	1	2	3	1	2
Sun	-	3	0	3	3	0	3
Vodafone	-	3	0	3	3	0	3
Coding Technologies	-	2	1	1	2	1	1
LG	-	2	1	1	31	16	15
Sony	-	2	0	2	2	0	2
Aepona	-	1	1	0	1	1	0
AMX	-	1	0	1	1	0	1
Canon	-	1	0	1	1	0	1
Casio	-	1	0	1	1	0	1
Cronin	-	1	0	1	1	0	1
Deutsche	-	1	0	1	1	0	1
Intel	-	1	0	1	1	0	1
KPN	-	1	1	0	1	1	0
LWICS	-	1	0	1	1	0	1
MP-1	-	1	0	1	1	0	1
SGS-Thomson	-	1	0	1	1	0	1
Sharp	-	1	0	1	1	0	1
Voiceage	-	1	1	0	1	1	0
Voicecraft	-	1	1	0	1	1	0
YRP Mobile	-	1	0	1	1	0	1

Table 6. Percent of Declared Patents Judged Essential
Ranked by Essential Percentage of all Families Reviewed

	2009 Study		2006 Study		All Families Reviewed	
	Declared Families	*Percent E/E**	*Declared Families*	*Percent E/E**	*Declared Families*	*Percent E/E**
Aepona	-		1	100	1	100
KPN	-		1	100	1	100
Voiceage	-		1	100	1	100
Voicecraft	-		1	100	1	100
Hitachi	1	0	15	27	16	69
Siemens	11	73	33	55	44	59
Nokia	64	50	198	52	262	52
LG	-		2	50	31	52
British Telecomm	4	50			4	50

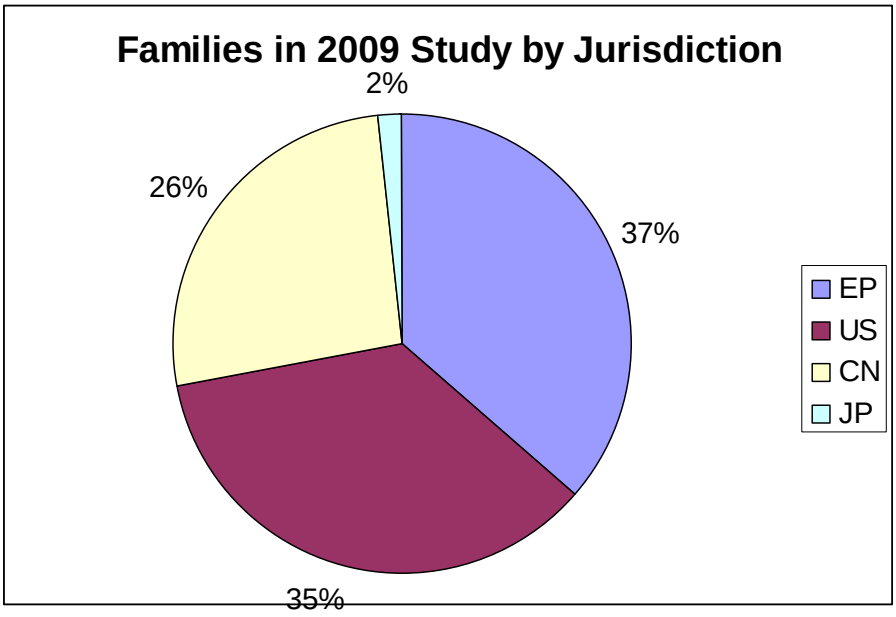
Innovative Sonic	2	50			**2**	**50**
Coding Tech	-		**2**	**50**	**2**	**50**
Huawei	111	46	**-**	**-**	**111**	**46**
Alcatel	7	71	**19**	**32**	**26**	**42**
Nortel	20	5	**17**	**24**	**37**	**38**
TI	1	0	**7**	**43**	**8**	**38**
Mitsubishi	-		**29**	**38**	**29**	**38**
Interdigital	2	0	**40**	**38**	**42**	**36**
Ericsson	48	33	**254**	**33**	**302**	**33**
ASUSTEK	4	50	**12**	**67**	**16**	**33**
ETRI	1	100	**2**	**0**	**3**	**33**
Raytheon	-		**3**	**33**	**3**	**33**
Motorola	5	80	**42**	**26**	**47**	**32**
NEC	5	60	**33**	**21**	**38**	**26**
NTT Docomo	6	50	**47**	**21**	**53**	**25**
NTT	-		**8**	**25**	**8**	**25**
France Telecomm	-		**4**	**25**	**4**	**25**
Matsushita	8	25	**45**	**22**	**53**	**23**
Research In Motion	5	20			**5**	**20**
Oki	-		**5**	**20**	**5**	**20**
Samsung	13	31	**41**	**10**	**103**	**15**
Philips	2	0	**24**	**17**	**26**	**15**
Apple	8	13			**8**	**13**
Qualcomm	36	25	**457**	**10**	**493**	**11**
Toshiba	-		**18**	**6**	**18**	**6**
Fujitsu	3	0	**22**	**5**	**25**	**4**

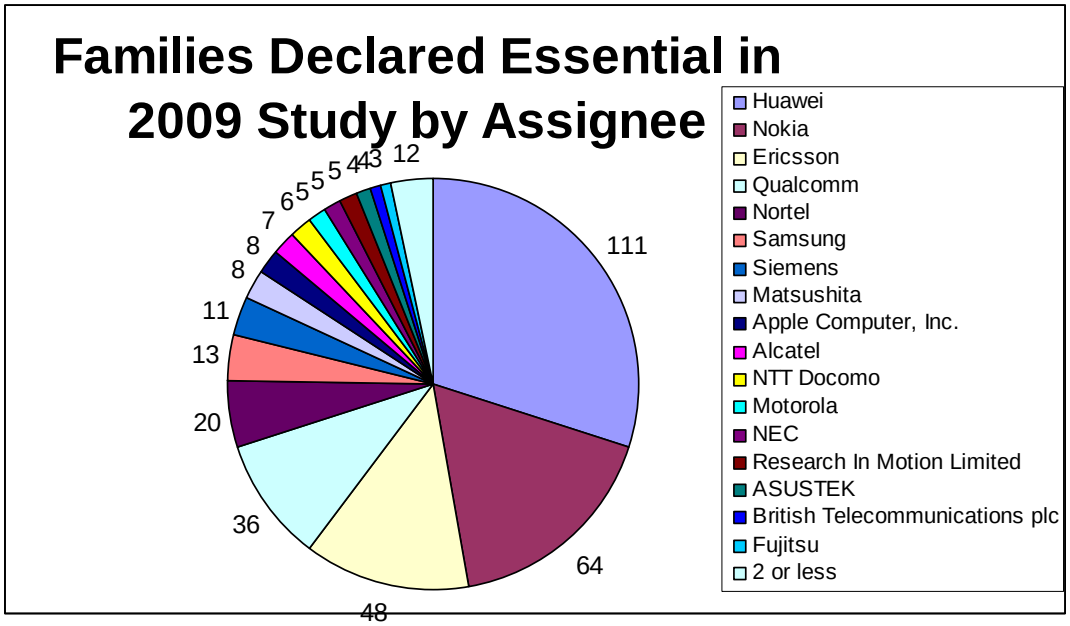
Table 7: Expiration Year of Essential Patents[44]

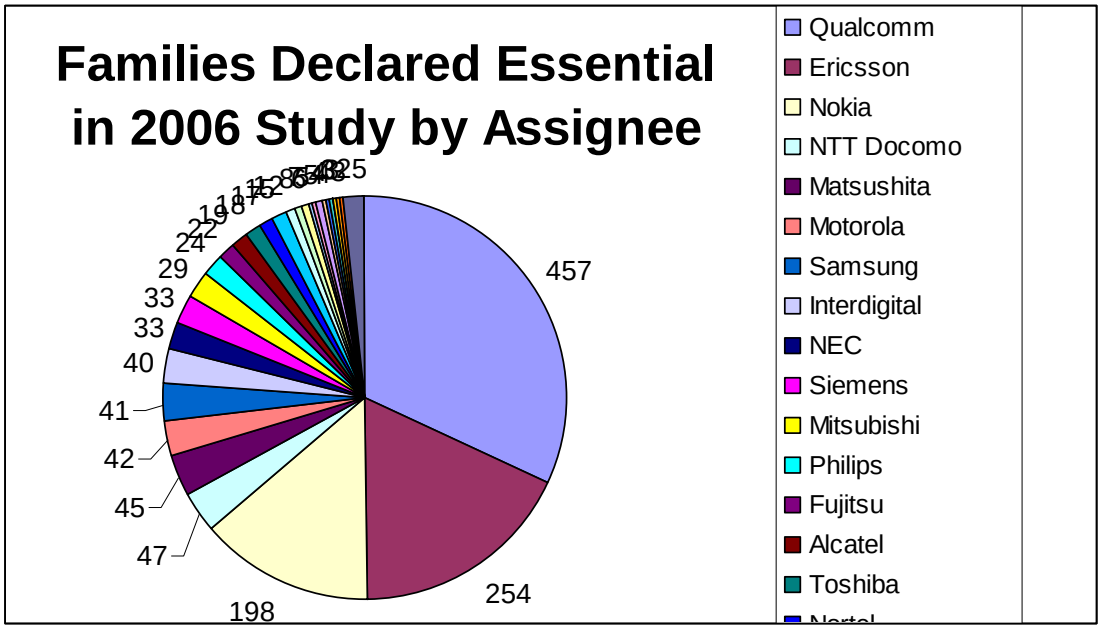
Expiration Year	2009 Study	All Studies
2009		2
2010		4
2011		4
2012		9
2013		5
2014	6	25
2015	6	17
2016	2	26
2017	2	32
2018	5	53
2019	5	77
2020	11	91

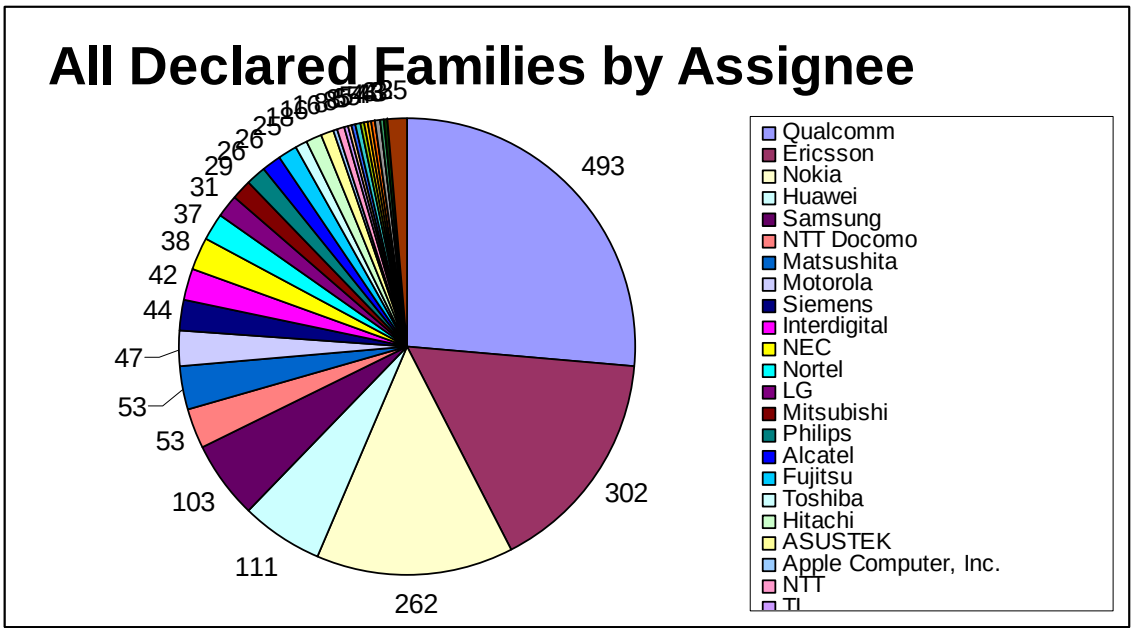
[44] Two of the patents judged essential in the 2006 study expired before 2009.

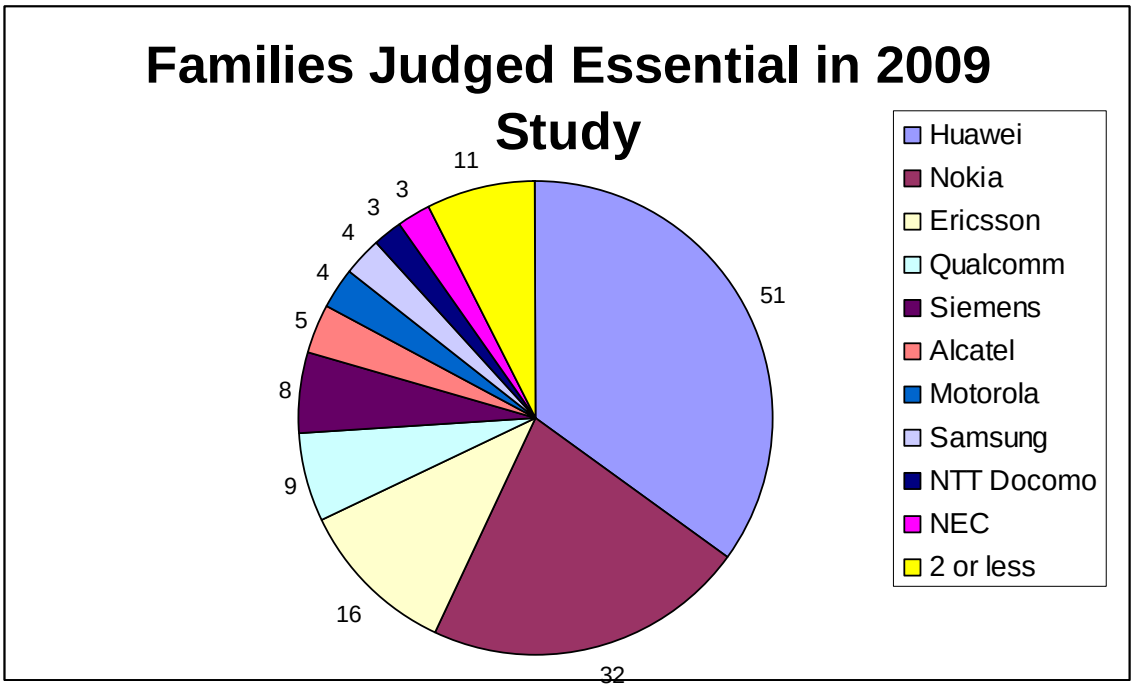
2021	20	61
2022	20	37
2023	18	25
2024	29	34
2025	18	18
2026	3	3
2027	1	1

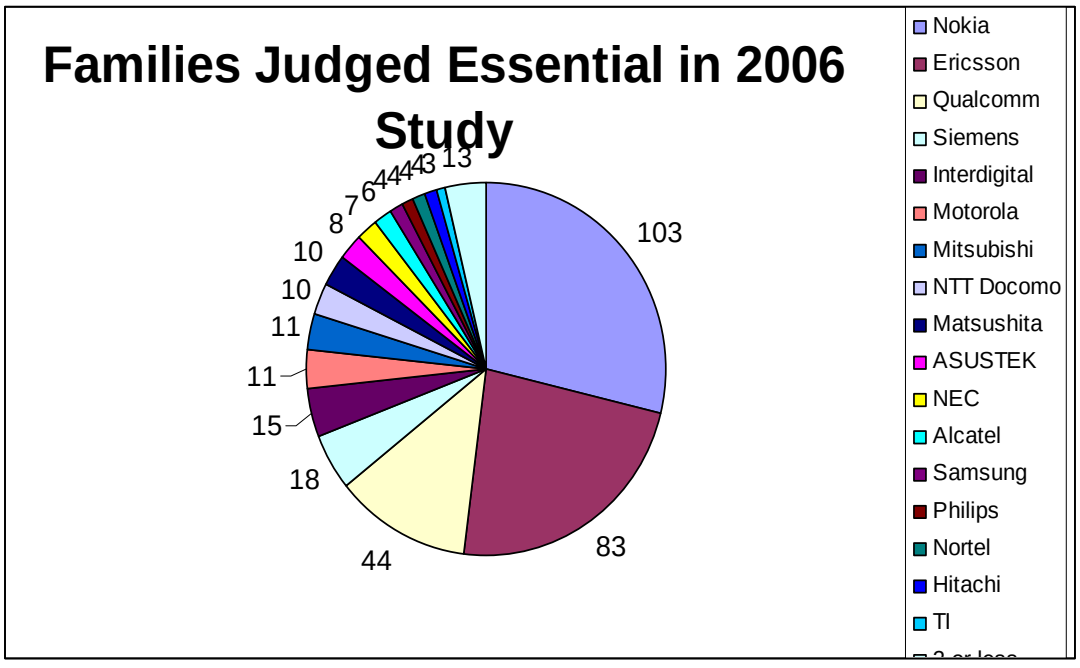


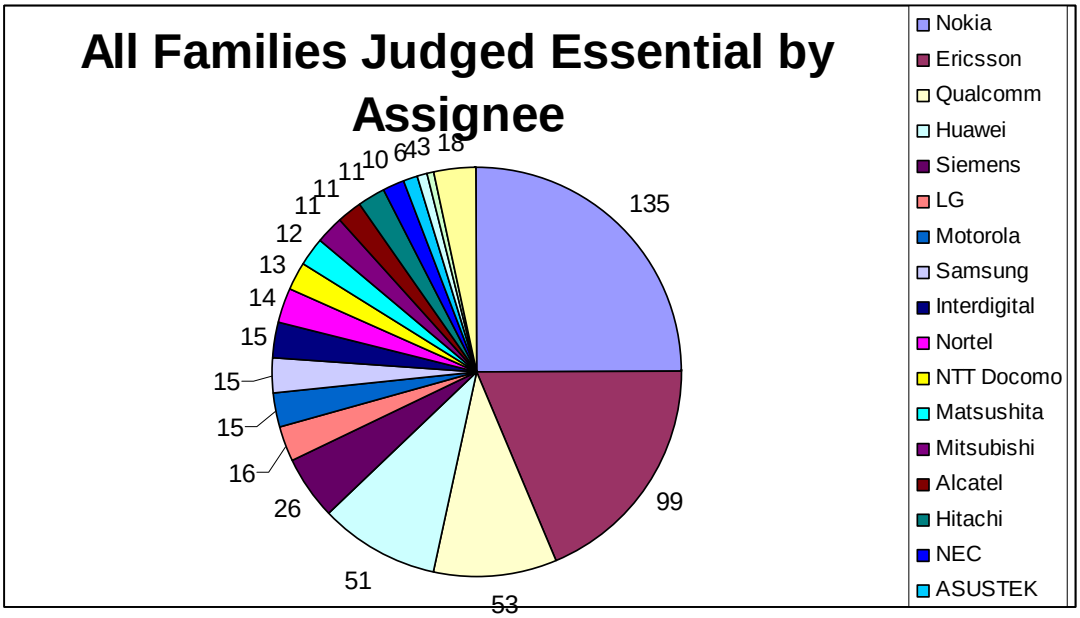












9 Patents Declared to the Korean Telecommunications Association as Essential to WCDMA Standards

Prior to the current study, we also examined 2838 patents and applications listed on the Korean Telecommunications Association (TTA) web site http://www.tta.or.kr/Home2003/committee/Ipr_PromiseList.jsp. Although the lists of declared patents and applications are primarily in Korean (a planned upgrade to English was not complete), we were able to identify 74 patent families with at least one issued US or EP (or both) patent that we had not previously reviewed for essentiality to WCDMA. These were all declared either by Samsung or LG. Where there were both US and EP patents in the family, we selected the EP patent for review. Where there were two or more patents in the same jurisdiction, we selected the most recently issued for our initial review. If, however, that patent was judged not essential, we then reviewed the remaining patents in that jurisdiction for their essentiality.

A total of 79 families, 43 US and 36 EP, were reviewed. 22 out of the 74 families (30%) were judged to have an essential patent. Of these, 15 are assigned to LG and 7 to Samsung. These results are included in the foregoing tables and charts as “Total Patents”.

The patents we reviewed were, as in our previous studies, assigned to one of eleven technology categories, listed in Appendix A. Only seven categories were found, with 22 of the 79 patents categorized as Layer2 and 16 categorized as channel coding. Ten of the 22 patents judged as essential – almost half - were in Layer2.

10 Discussion of our Results

10.1 Evolution of Technology Categories of Declared Patents

In Fairfield's latest study, 20% of the patents claimed technology in more than one category. In this report, we refer to only one category per patent, the one that we identified as most prominent in the patent claims. Although the patents covered 15 technology categories, Table 1 and the pie chart in Figure 1 show that the distribution across categories is very uneven.

The study is dominated by patents in the Network category (115 families, 31%). The next two categories - Layer 2 and Radio Resources Management - together account for another 114 families, also 31%. Seven categories account for the next 116 families (also 31%). The remaining 24 families are distributed among 5 categories. In view of the increased importance of network categories, we have provided an expanded explanation of their definitions, as follows:

Layer 2

Certain cellular communications signals share the same channel with one another. Layer 2 protocols, especially media access control (MAC), establish rules for granting access to one signal at a time while the other signals wait their turn. Other Layer 2 protocols deal with signals that have not been received correctly. The receiver instructs the transmitter to send additional information that will enable it to detect the original signals correctly. Error detection and retransmission are together referred to as ARQ (automatic repeat request, an old telegraphy term). Patents in the 2009 study disclose increasingly sophisticated and efficient ARQ techniques, many of them referred to as "hybrid ARQ" or incremental redundancy. Another term is "Layer 1 ARQ" reflecting the fact that error detection and retransmission are combined with forward error correction (FEC).

Location

In order to set up communication with a mobile phone, the network has to know which base station the phone is in contact with. To make this possible, an inactive phone sometimes sends a registration message to the network. When the network has to set up communication, it pages the phone at base stations near the one that received the latest registration message. The patents also disclose technology for determining the geographical coordinates of a phone (or other wireless device)[45]. Several patents in the Location category of the 2009 study are concerned with location determination, either finding the geographical coordinates of mobile devices or communicating this information within a cellular network or between a cellular network and independent service providers.

[45] This is particularly important in making a "911" emergency call.

Network

Techniques for coordinating the operations of elements of a cellular telephone system's infrastructure, including base stations, switching centers, routers, and databases. This category also includes patents covering network management procedures for maintaining the long term health of a network and insuring that it meets quality objectives. The telephone industry sometimes refers to OA&M: operations, administration, and maintenance. Examples include fault location and provisioning (deciding where and when to replace old equipment or add new equipment to a growing network). In the 2009 Fairfield study, patents in the Network category address interaction between cellular networks and Wireless Local Area Networks. Other Network patents define procedures and protocols for delivering new services to mobile devices. Two examples are multimedia broadcast/multicast services (MBMS) and location dependent services.

It is instructive to compare the technology categories in the 2009 Fairfield study with those reported by Fairfield in 2006, covering two earlier studies of patents declared essential to 3G cellular technology standardized by 3GPP. Those studies included 1428 patent families with patents declared essential to 3GPP standards prior to January 1, 2006. In that study the network category was fifth most prominent with only 107 families (7.5% of the total). The largest category was Radio Resources Management with 237 patents (17% of the total).

The high proportion of Network patents in the 2009 study is due to the fact that one of the main goals of 3GPP standards creation in recent years has been to bring cellular networks in line with the Internet. The Network patents can be divided into a few subcategories. In common with most of the Network patents in the earlier Fairfield studies, some of the patents in the 2009 study describe protocols for communication between various elements of the Core Network. Another set of patents addresses interaction between cellular networks and Wireless Local Area Networks. With WiFi modems standard in practically all portable computers and features of many cellular smartphones, there are many advantages of linking WiFi systems with cellular networks.

Other Network patents define procedures and protocols for delivering new services to mobile devices. Two examples are multimedia broadcast/multicast services (MBMS) and location dependent services. We have assigned the category "Location" to most of the patents that deal with location dependent services. Originally, the Location category dealt with procedures used to track the locations of mobile devices in order to deliver incoming phone calls and other types of information such as short messages. Registration and paging procedures are at the heart of "location management" in cellular networks. Many patents in the Location category of the 2009 study have to do with location determination, either finding the geographical coordinates of mobile devices or communicating this information within a cellular network or between a cellular network and independent service providers. Some of this communication requires authorization by subscribers or service providers, and thus intersects the "Security" category.

The Network category in the 2009 Study also includes patents that relate to charging subscribers for services. Originally, charging for services was the proprietary concern of cellular operating companies. With the possibility of obtaining services from other networks and in the interest of giving consumers more control of the cost of the services they obtain, patents in the 2009 study describe network elements referred to a "charging centers", communications between charging centers and other network elements, and methods of notifying subscribers of charges for services they might purchase.

Another departure from the earlier Fairfield studies is the higher proportion of patents in the "Layer 2" category: 16% in 2009 compared with 7% in the earlier studies. Layer 2 technologies include Media Access Control and error detection and retransmission. Engineers refer to retransmission procedures as ARQ (originally a telegraphy acronym for "automatic repeat request"). Newer cellular systems have incorporated increasingly sophisticated and efficient ARQ techniques, many of them referred to as "hybrid ARQ" or incremental redundancy. Another term is "Layer 1 ARQ" reflecting the fact that error detection and retransmission is combined with forward error correction (FEC). FEC technologies in the earlier studies have had their own category: "Channel Coding".

On the other hand, the percentage of patents in the radio signals category is much lower in the 2009 study (4%) than it was in the earlier Fairfield studies (13%). This change reflects the fact that the earliest emphasis in 3GPP was standardization of the WCDMA technologies at the heart of the 3G radio access network. By the end of 2005, these technologies were well established and subsequently there were relatively few new patents declared essential to them.

All in all the distribution of patents across technology categories in the 2009 Fairfield study reflect the main thrusts of technology creation in the present decade. The nature of the patents suggests that it might be fruitful to reformulate the technical categories in future studies, perhaps subdividing some of the original categories such as Network and Location and consolidating others (Radio Signals, Channel Coding).

10.2 Evolution of Ownership of Essential Patents

Qualcomm, Ericsson, Nokia, Huawei and Samsung now dominate the rank of owners of declared essential patents, with two thirds of the total. In contrast, in our 2006 study Qualcomm, Ericsson and Nokia alone owned more than 60% of the patents we studied; Samsung had less than 3% and Huawei had none. Nokia and Ericsson and, to a lesser extent, Qualcomm continue to maintain a high rate of declarations in our latest study, but Huawei is a standout, with all of their declarations coming in the year 2000 and later; Samsung's large increase in declarations stems from their declarations to the Korean TTA.

The four largest owners of declared patents also own the lion's share of patents our experts judged essential, 65% - very close to their share of total patents. However, this percentage is skewed by the Huawei and (new) Nokia declarations, almost 50% of which our experts judged as essential. Consequently, the percentage of patents found essential in

our extension study was about 38%. In spite of this high percentage, the total sum of patents judged essential by our experts is still only 27%.

Our current results also indicate a number of new players in the essential patent field, particularly Apple (8) and Research in Motion (5). This probably reflects the new focus in wireless technology on interworking with the Internet and Smartphones.

We also see that the great majority of the patents judged essential do not expire until 2021 or later, indicating that they were filed after the year 2001. This is not surprising, since patents filed earlier than that would likely have issued in time to be reviewed in one of our earlier studies.

We have no indisputable argument as to why our experts judged so many patents to be essential in the current review. The team is substantially the same as previously so it is not likely that we have suddenly engaged a group of "easy graders". Since such a high proportion of the newly reviewed patents are Chinese patents, however, it is possible to argue that the "easy graders" were the Chinese examiners, who overlooked prior art that might have precluded US or EP examiners from allowing the claims. This assertion might be checked in time as the patent families with an allowed CN patent are reviewed by US and EP patent offices.

It is interesting to speculate on the possibility that inventors have been paying attention to our publications and presentations, and are now more careful (with their attorneys) to actively pursue patents which, if issued are more likely to be essential. Another more positive explanation for the high hit rate in our current study may lie in the nature of Release 7 of the standards, and in the skewed distribution of technology categories of the declared patents. That is, Release 7 is more focused on interworking with the Internet and Smartphones and Internet protocols in general, and this is an area where the prior art has been less dense and the opportunities for covering an essential standard are broader.

A simple explanation for the relatively "high" percentage of E/E* patents in the 2009 study, however, can be seen from Table 7, the percentage of families declared essential which were judged essential by our experts. We found about 33% of the families declared essential in the 2006 review were declared by Qualcomm, but only 11% of these were actually judged essential. This clearly skewed the earlier results, while in 2009 only 10% of the declared families were declared by Qualcomm.

At this point in our research, we believe that the evolution of fourth generation wireless technologies, LTE ("Long Term Evolution") and Wi-Max, have reached the point at which it is appropriate to investigate the role that essential patents may play in this further evolution of wireless technology.

10.3 Significance of the 2009 results

Wireless technology and standards have been evolving at a fast pace over the past decade and a half, and the patents that may read on the standard have been following and often

leading this evolution. For the most part the technology leaders have continued to lead in obtaining patents which our experts judged to be essential, although companies with challenges in the marketplace such as Motorola now lag. In contrast, Huawei, an emerging industry leader, has emerged as a patenting leader, now overshadowing Japanese companies. Samsung, too, is now an important patentee and will likely be more so as more of its applications issue[46].

The technology emphasis of the patents reported in this study is now highly focused on the network aspects of the system, while many of the elements that were necessary in order to install and operate early systems are now receiving less attention both from the standards committees and from inventors. It will be interesting to see if this trend caries over to the new fourth generation systems, LTE and Wi-Max.

It continues to be clear that participating in most aspects of wireless communications requires either licenses to a growing number of patents, or comparable protection (e.g., by supplying to a licensee) from infringement allegations.

10.4 Limitations of this Research

The evaluations performed by the experts in this study are *preliminary technical* assessments. By contrast, determining the scope of a patent and its commercial value can consume several days of effort by lawyers and engineers and weeks or months of adjudication by judges and juries. Therefore we suggest that the data be regarded as a valid statistical evaluation of the ownership and technology covered by patents that are essential to implementing the WCDMA standards. Our methodology, which includes reviews of different patents by different experts as well as a significant number of reviews of the same patents by different experts, embodies controls across the large number of patents reviewed which assure the reliability of the analysis on an aggregate basis. It may also be necessary to judge the *validity* of the patent claims judged to be technically essential. Even though some of these claims are extremely broad, the experts did ***not*** assess their validity.

We also note that WCDMA networks adopt protocols standardized for GSM telephone communications and GPRS packet data communications. It follows that patents essential to GSM and GPRS can also be essential to WCDMA[47]. Patents that were declared to ETSI as essential to these standards were not included in the results reported here unless they were also declared as essential to the 3G standards (UMTS, 3GPP and AMR).

We draw the attention of readers to several other limitations to our study. With regard to patent ownership, we are aware that it is not unusual for a company to acquire the rights to patents invented by outsiders. As a consequence our data are not precise indicators of who owns declared and essential intellectual property. The actual ownership distribution

[46] In the current study we did not revisit the TTA declarations to see if any of the previously unissued applications now have issued US or EP counterparts.
[47] For example, the speech-related standards for GSM and WCDMA are very similar; in some cases, identical.

would take into account agreements that transfer patent rights from the company identified on the patent to another company.

It is also important to address the status of the essentiality data. In practice, the value of a patent depends on several *legal* and *commercial* factors. By contrast, the evaluations performed by the panel in this study are *preliminary technical* assessments, based on an average of one hour of analysis per patent. Determining the scope of a patent and its commercial value, if any, requires several days of effort by lawyers and engineers, and sometimes weeks or months of adjudication by judges and juries[48]. In addition to the relationship of a patent to practical equipment and services, it is also necessary to consider patent *validity*. It is common for a company to assert that a competitor's patents are invalid and therefore unenforceable, either due to flaws in the patent itself or due to the fact that the claimed technology already existed when the inventor filed the patent application.

Another factor is the dynamic nature of both standards and intellectual property. By necessity, the standards cover existing proven technology, while patent applications describe novel techniques. Many of the patents were declared to be essential to technical specifications that were under consideration but not yet published when the patent applications were submitted. FRI took great pains to identify declared patent applications which subsequently issued within our window. Both 3GPP and 3GPP2 continue to refine and enhance the standards. They regularly publish new and revised Technical Specifications, so that some of the patents that were judged not essential to specifications published before 2004 may be essential to present-day specifications or specifications to be published in the future. The increase in the number of patents our experts found to be essential in the current study is one indication of the evolution in both the standards and in the ability of inventors to tune their inventions and patents to the evolving standards.

[48] Spending many hours or days reviewing each one of almost 2000 patent families is neither necessary nor realistic. Some of our expert reviewers have been engaged in this exercise for five or more years and all are intimately familiar with the standards. Since many of the patents are clearly not essential, we therefore believe there has been ample time to study the more complex patents. We do not believe that the results of our study would be changed substantively had our time budget been increased.

Appendix A: Technology Category Definitions

Antenna

Most of the antenna patents apply to base stations and or terminals with more than one antenna. The patents specify how to coordinate transmissions from multiple antennas and how to combine signals received on multiple antennas.

Call management

Procedures for establishing, maintaining, and breaking connections between devices in a phone call or a data session.

Channel coding

Wireless communications systems are vulnerable to transmission errors (the transmitter sends "one", the receiver detects "zero"). Channel codes add redundancy (extra ones and zeros) so that the correct transmission can be detected by the receiver even if some of the ones and zeros have been reversed.

Circuits

Electronic circuits for realizing functions specified in the standards.

Data

Techniques for communicating digital data (as distinct from voices or pictures). Many of the patents in this category apply generally to data transmission techniques, not necessarily cellular (even though they may have been devised as part of 3G cellular development and included in 3G standards).

Facsimile

Communicating standard telephone fax signals in a 3G network.

Handover

Transferring a communication from one antenna in the fixed part of the radio access network to another.

Layer 2

Certain cellular communications signals share the same channel with one another. Layer 2 protocols, especially media access control (MAC), establish rules for granting access to one signal at a time while the other signals wait their turn. Other Layer 2 protocols deal with signals that have not been received correctly. The receiver instructs the transmitter to send additional information that will enable it to detect the original signals correctly. Error detection and retransmission are together referred to as ARQ (automatic repeat request, an old telegraphy term). Patents in the 2009 study disclose increasingly sophisticated and efficient ARQ techniques, many of

them referred to as "hybrid ARQ" or incremental redundancy. Another term is "Layer 1 ARQ" reflecting the fact that error detection and retransmission are combined with forward error correction (FEC).

Location

In order to set up communication with a mobile phone, the network has to know which base station the phone is in contact with. To make this possible, an inactive phone sometimes sends a registration message to the network. When the network has to set up communication, it pages the phone at base stations near the one that received the latest registration message. The patents also disclose technology for determining the geographical coordinates of a phone (or other wireless device)[49]. Several patents in the Location category of the 2009 study are concerned with location determination, either finding the geographical coordinates of mobile devices or communicating this information within a cellular network or between a cellular network and independent service providers.

Network

Techniques for coordinating the operations of elements of a cellular telephone system's infrastructure, including base stations, switching centers, routers, and databases. This category also includes patents covering network management procedures for maintaining the long term health of a network and insuring that it meets quality objectives. The telephone industry sometimes refers to OA&M: operations, administration, and maintenance. Examples include fault location and provisioning (deciding where and when to replace old equipment or add new equipment to a growing network). In the 2009 Fairfield study, patents in the Network category address interaction between cellular networks and Wireless Local Area Networks. Other Network patents define procedures and protocols for delivering new services to mobile devices. Two examples are multimedia broadcast/multicast services (MBMS) and location dependent services.

Radio signals

These patents cover the signals transmitted between terminals and base station. Many of them relate to CDMA codes (sequences of ones and zeros used to transmit each unit of information). Others present modulation techniques that transform the ones and zeros into radio signals to be transmitted at specified frequencies.

Radio resources

Efficiently managing transmitter power levels and bandwidth occupancy of the signals that share the same radio spectrum.

[49] This is particularly important in making a "911" emergency call.

Security

Encryption of information to prevent eavesdropping. Authentication to ensure that only authorized users have access to networks.

Source coding

Compression techniques for representing speech and pictures as a sequence of numbers.

Synchronization

Base stations and terminals transmit sequences of ones and zeros, divided into data units, each containing a prescribed number of ones and zeros. Synchronization techniques enable a receiver to determine the beginning and end of each data unit within a continuous binary data stream.

TDMA

Time division multiple access. Signals sent to and from different terminals are transmitted at different times.

Terminal

Patents covering technologies located entirely or predominantly in subscriber equipment. Some of these patents cover SIM (subscriber identity modules). Others cover over the air programming of terminals.