

# Review of Patents Declared as Essential to LTE and SAE (4G Wireless Standards) Through June 30, 2009<sup>1</sup>

Fairfield Resources International, Inc.<sup>2</sup>

Darien, CT, USA

January 6, 2010

## 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 five such studies have been completed, three of which are in the public domain:

- Patents declared to ETSI<sup>3</sup> and ARIB<sup>4</sup> as essential to WCDMA Release 4 and CDMA2000 through December 31, 2003<sup>5</sup>
- Patents declared to ETSI as essential to GSM<sup>6</sup> through June 6, 2007.
- Patents declared to ETSI and ARIB as essential to WCDMA Release 6 through February 1, 2005
- Patents declared to the Korean TTA<sup>7</sup> as essential to WCDMA through January 1, 2006
- Patents declared to ETSI as essential to WCDMA Release 7 through December 31, 2008<sup>8</sup>

The present report, using substantially the same team of experts as in our previous studies<sup>9</sup>, extends our reviews to patents declared as essential to two fourth generation cellular technologies, LTE (the radio access interface) and SAE (the core network)<sup>10</sup>.

There were 1115 patents and patent applications declared as essential to 3GPP Release 8 (LTE and SAE) as of July 1, 2009. Among these there are 210 families with at least one issued United States (US), European (EP) or Chinese (CN) patent. Fairfield Resources examined patents in each of these families to

---

<sup>1</sup> Robert A. Myers is responsible for the content of this report. David J. Goodman made a significant technical contribution.

<sup>2</sup> This study was funded by Nokia which, however, was contractually bound to exert no influence on its content.

<sup>3</sup> ETSI: European Telecommunications Standards Institute

<sup>4</sup> ARIB: Association of Radio Industries and Businesses

<sup>5</sup> David J. Goodman and Robert A. Myers, *3G Cellular Standards and Patents*, IEEE Wireless2005 Proceedings, available at [www.frlicense.com](http://www.frlicense.com)

<sup>6</sup> David J. Goodman and Robert A. Myers *Analysis of Patents Declared as Essential to GSM as of June 6, 2007*, (unpublished), available at [www.frlicense.com](http://www.frlicense.com)

<sup>7</sup> TTA: Telecommunications Technology Association

<sup>8</sup> <http://www.frlicense.com/WCDMA%202009%20Report%20for%20Web.pdf>

<sup>9</sup> The team consisted of 4 Ph.D. and 2 M.Sc. telecommunications engineers with an average of 11.5 years' experience. They are associated with a highly regarded contract research and development organization that specializes in the analysis, evaluation and design of advanced mobile radio technologies and equipment. Many of them have significant publication records and three are native speakers of Chinese.

<sup>10</sup> Wi-Max, also a fourth generation wireless standard, is not covered in this report.

determine whether the family contains one or more patents judged essential or probably essential by its team of experts. Of these 210 families, 105 families (50%) have at least one patent judged essential (E) or probably essential (E\*). In all, there were 375 patents reviewed in this study.

Some of the salient departures of the findings in this study from the findings in the 2009 Fairfield WCDMA study are:

- The large fraction (50%) of patent families with at least one essential patent, compared with 39% in the 2009 Fairfield WCDMA study,
- The large fraction (48%) of patent families owned by Nokia compared with 19% in the 2009 Fairfield WCDMA study,
- The small number of declared Chinese patent applications that resulted in patents issued prior to July 1, 2009.
- The preponderance of air interface patent families in this study.

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”. Note more than half of the families in this review had at least one US and one EP patent. Almost two-thirds of those families had at least one essential patent.

Table E-1 Summary of patent families evaluated

| <b>Patents in Family</b>     | <b>Families Reviewed</b> | <b>Families with a Patent Judged E/E*</b> | <b>Families with all Members Judged N/N*</b> | <b>Per Cent E/E*</b> |
|------------------------------|--------------------------|---|--|----------------------|
| European patent(s) only      | 7                        | 4   | 3  | 57                   |
| United States patent(s) only | 86                       | 29  | 57   | 33                   |
| Chinese patent only          | 4                        | 2   | 2  | 50                   |
| Both US and EP patent(s)     | 113                      | 70  | 43   | 63                   |
| <b>Total</b>                 | <b>210</b>               | <b>105</b>                                | <b>105</b>                                   | <b>50</b>            |

As shown in Table E-2, the category with the largest number of families is “layer 2”. However the proportion of the total (19%), is much lower than the proportion of families in the “network” category in our latest WCDMA study (31%). The present study also contains 23 “antenna” families, all but one of them claiming MIMO (multiple input multiple output) techniques. The percentages shown in Table E-2 refer to the total number of families reviewed, 210 families in the LTE.SAE study and 380 families in the WCDMA study

Table E-2: Technical categories declared essential

| Technical category | Families with Patents declared Essential to LTE/SAE in this Study |         | Families with Patents declared Essential to WCDMA in 2009 Study |         |
|--------------------|---|---------|---|---------|
|                    | number  | percent | number  | percent |
| Layer 2            | 41  | 19      | 60  | 16.2    |
| Radio resources    | 29  | 14      | 54  | 14.6    |
| Antenna            | 23  | 11      | 9   | 2.4     |
| Network            | 22  | 11      | 115   | 31.1    |

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

| Technical category | Families with Patent Judged Essential to LTE/SAE in this Study |         | Families with Patents Judged Essential to WCDMA in 2009 Study |         |
|--------------------|--|---------|---|---------|
|                    | number   | percent | number  | percent |
| Layer 2            | 23   | 22      | 29  | 20      |
| Radio resources    | 11   | 10      | 20  | 13      |
| Antenna            | 9  | 9       | 1   | .7      |
| Network            | 13   | 12      | 54  | 37      |

Although Ericsson, Nokia and Qualcomm continue to lead in the total number both of patents declared essential and patents judged essential, almost half of the LTE/SAE families were declared essential by Nokia. Moreover Nokia owns 54% of the patents judged essential. There were only three Huawei families with an issued patent, and none from Samsung.

Table E-4. Leading Owners of Declared IP

|                 | LTE/SAE Study |      |      | 2009 WCDMA Study |      |      |
|-----------------|---------------|------|------|------------------|------|------|
|                 | Total         | E/E* | N/N* | Total            | E/E* | N/N* |
| <b>Huawei</b>   | 3             | 1    | 2    | 111              | 51   | 60   |
| <b>Nokia</b>    | 102           | 57   | 45   | 72               | 35   | 32   |
| <b>Ericsson</b> | 24            | 14   | 10   | 48               | 16   | 32   |
| <b>Qualcomm</b> | 26            | 8    | 18   | 35               | 9    | 27   |

## 2. Content of this report

In the interests of brevity, we have omitted considerable relevant material that may be found in our previous reports. The primary novelty in this report, apart from the data on the declared patents our experts reviewed and those they judged essential, is a discussion of the technology content of the declared patents.

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.

## 3. Essential Patents

The 3G Partnership Projects 3GPP and 3GPP2 and their constituent standards organizations encourage individual members to “declare” patents and patent applications that they believe are “essential” to implementing third and fourth 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<sup>11</sup>.*

Lists of patents declared essential to LTE and SAE appear at the web site of the European Telecommunications Standards Institute (ETSI)<sup>12</sup>. Lists of patents declared essential to CDMA2000 and WCDMA appear at the web sites of ETSI, the Association of Radio Industries and Businesses (ARIB)<sup>13</sup>, The Telecommunication Technology Committee (TTC)<sup>14</sup>, and the Telecommunications Technology Association (TTA).<sup>15</sup> ARIB and TTC are Japanese standards organizations, while the TTA is a Korean organization. All of these sites are accessible in English. As of December, 2008, we identified more than 10,000 patents and then-pending applications declared as essential to WCDMA

The most recent release of the 3GPP standards is Release 8.0, which addresses so-called Fourth Generation Wireless. There are more than 1100 patents and applications declared as essential to LTE and SAE as of July 1, 2009. We analyzed these declarations and identified a total of 210 distinct families in which there was at least one issued US, EP, or CN patent [There were no issued JP patents]. Our expert team has analyzed these families, following the procedure practiced in our previous reports. That is, the most

---

<sup>11</sup> “ETSI IPR Policy”, Nov. 22, 2000. [http://www.etsi.org/legal/documents/ETSI\\_IPRPolicy.pdf](http://www.etsi.org/legal/documents/ETSI_IPRPolicy.pdf)

<sup>12</sup> [www.etsi.org](http://www.etsi.org)

<sup>13</sup> [www.arib.or.jp](http://www.arib.or.jp)

<sup>14</sup> [www.ttc.or.jp](http://www.ttc.or.jp)

<sup>15</sup> [www.tta.or.kr](http://www.tta.or.kr)

recently issued US or EP patent in the family was reviewed; if it was judged “E/E\*”, then the family was judged an essential family. If the first patent reviewed was judged N/N\*, then the next most recently issued patent was analyzed, and so on until a family member was judged E/E\*. If no member was found to be E/E\*, then the family was judged a non-essential family.

#### **4. Declared patents**

Our source for patents and patent applications declared essential to LTE and SAE technology is the ETSI web site. We believe that nearly all declarations of essentiality to LTE and SAE are currently posted on this site. Of the 210 families in which we found an issued United States, European or Chinese patent, 166 families were declared as essential to LTE and 44 families, all owned by Nokia, were declared as essential to SAE. However, each patent family was reviewed for essentiality to both standards.

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 4G standards means that patents declared as essential to an earlier standard such as GSM, TDMA or EDGE may also be essential to WCDMA, LTE, or SAE.

After clustering the patents into families, we chose one patent from each family for further analysis. To select a patent declared essential to LTE or SAE we first looked at the most recently issued EP or US patent. If there was no European or United States patent in the family, we selected a Chinese patent if there was one.

#### **5. Process Followed in the Fairfield Study**

The lists of patents and patent applications declared as essential to LTE or SAE compiled by ETSI contains more than 1100 distinct entries declared as of June 30, 2009. Each patent or application is published by either a national patent issuing office or the European Patent Office. However, the number of inventions may be considerably less than 1100 because it is customary for inventors to patent a single invention in many different countries.

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 resulted in an issued patent. The study evaluated patents issued and declared as essential to the extent this information

is available<sup>16</sup> on or before June 30, 2009. We then tabulated all the issued US and EP patents in that patent family, using Delphion.com and Espacenet.com.

The details of the process we followed are substantially the same as those followed in our previous reviews, and may be found in the most recent report. In practice, the process was simplified by the limitation to patents declared only to ETSI, and by the observation that these patents fell into relatively few national jurisdictions. For example, only four Chinese language patents were found to have issued, and there were no issued Japanese applications.

Most important, although we initially selected the most recently issued patent in a family (see above), if that patent was judged not essential (N) or probably not essential (N\*) by our experts, we proceeded to analyze in succession *all* of the US and EP patents in the family until we found one judged essential (E) or probably essential (E\*). This procedure resulted in evaluations of 375 patents in the 210 patent families in the study.

## 6. 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, reference should be made to our previous report, where the concept is discussed in considerable detail.

**Caveat.** Since we eventually examine every patent in a family until we find an essential patent, our process provides assurance that if there is at least one essential patent in the family, we will review it and classify the family as “essential”. One contributor to possible errors arises from the fact that in the definition of family member followed by INPADOC<sup>17</sup> 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<sup>18</sup> or Espacenet<sup>19</sup> 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 few – 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 locate an essential patent in such a family if there is one, but other essential “family” members covering different essential inventions may not be found. There were three such “megafamilies” analyzed in the current study, one assigned to Ericsson and two assigned to Interdigital. All of the thirty

---

<sup>16</sup> ARIB does not make the date of declaration available.

<sup>17</sup> INPADOC: **I**nternational **P**atent **D**ocumentation Center, an international patent collection database produced and maintained by the European Patent Office (EPO).

<sup>18</sup> [www.delphion.com](http://www.delphion.com)

<sup>19</sup> [www.espacenet.com](http://www.espacenet.com)

patents in one of the families were reviewed, with one found essential; the thirteen patents in a second such family were all reviewed and judged not essential. However, in the third such family, with 64 members to be reviewed, after we found an essential patent fifty family members still were not reviewed. It is quite possible that one or more additional patents in this family could have been found essential, but, even if that were the case, we do not think they would have a material effect on our overall findings.

## 7. Results of the 2009 LTE/SAE Study

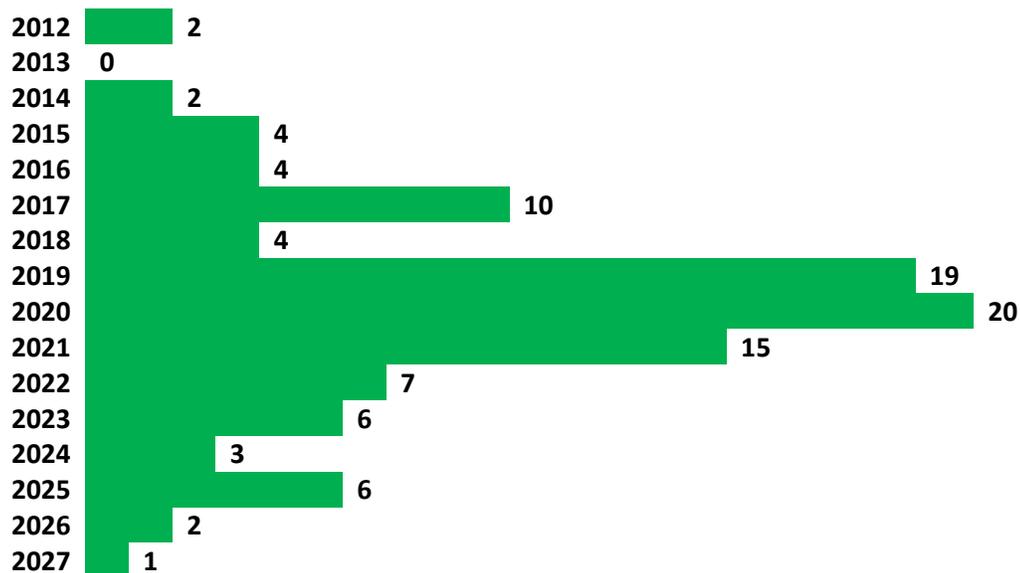
### 7.1 Summary

The results of the selection process are summarized in Table 1, which shows the number of patent families selected in the four jurisdictions and our experts' opinions.

Table 1 Summary of patent families evaluated

| <b>Patents in Family</b>     | <b>Families Reviewed</b> | <b>Families with a Patent Judged E/E*</b> | <b>Families with all Members Judged N/N*</b> | <b>Per Cent E/E*</b> |
|------------------------------|--------------------------|---|--|----------------------|
| European patent(s) only      | 7                        | 4   | 3  | 57                   |
| United States patent(s) only | 86                       | 29  | 57   | 33                   |
| Chinese patent only          | 4                        | 2   | 2  | 50                   |
| Both US and EP patent(s)     | 113                      | 70  | 43   | 63                   |
| <b>Total</b>                 | <b>210</b>               | <b>105</b>                                | <b>105</b>                                   | <b>50</b>            |

Table 2. Expiration Year of Patents Judged Essential



## 7.2 Discussion of Results

### 7.2.1. LTE Technology

In Autumn 2009, Fairfield Resources evaluated patents declared essential to two sets of technical standards published by the Third Generation Partnership Project (3GPP): Long Term Evolution (LTE) and Service Architecture Evolution (SAE). Together the technologies specified in these standards are sometimes referred to as “4G”, fourth generation cellular communications. They are the most recent members of a sequence of standards published by 3GPP and adopted by cellular operating companies throughout the world. The second generation system based on these standards, GSM, appeared in the early 1990s. Third generation technology, sometimes referred to as WCDMA or UMTS, appeared ten years later. The first commercial implementations of LTE/SAE appeared in Norway and Sweden in 2009<sup>20</sup>. Widespread deployment is anticipated in 2010 or 2011.

Major innovations in LTE revolve around two new air interface technologies based on frequency division multiple access (FDMA). Transmissions in the forward direction (base station to terminal) use orthogonal frequency division multiplexing (OFDM). Transmissions in the reverse direction use single carrier FDMA. The 4G radio signals can be spread over a considerably wider bandwidth, up to 20 MHz, than the bandwidths occupied by 3G CDMA signals (5 MHz) and 2G TDMA signals (0.2 MHz).

### 7.2.2. Technical categories of in the LTE air interface

High bandwidth efficiency in FDMA can be achieved through adaptive modulation and coding and advanced antennas using multiple-input-multiple-output (MIMO) techniques. Innovations in modulation and coding per se appear in patent families in the *radio signals* category and the *channel coding* category. Adaptation to changing channel conditions relies on channel quality estimation and scheduling of subcarriers. Patent families claiming channel quality estimation and scheduling are in the *radio resources* category. LTE also contains *handover* innovations and innovations in the *layer 2* category.

Layer 2 inventions include media access control (MAC) and automatic repeat requests (ARQ). ARQ techniques include detection of transmission errors and retransmission of signals that encounter errors. Relative to earlier systems LTE includes many patents related to “hybrid ARQ.” Unlike earlier systems that discard received data units containing errors, systems with hybrid ARQ extract useful information from the signals with errors and augment it with information in subsequent transmissions in order to

---

<sup>20</sup> TELIASONERA OFFERING WORLD'S FIRST COMMERCIAL LTE SERVICES, [WWW.CRN.COM](http://www.crn.com)  
<http://www.crn.com/networking/222001881.jsessionid=FZNPBSNI4L4SPQE1GHPSKH4ATMY32IVN>

correctly detect received signals. The other categories with patents declared essential to the LTE air interface are *antenna*, *electronic circuits*, and *source coding*.

### 7.2.3. Other technical categories

There are patent families declared essential to LTE/SAE that cover technologies in five technical categories that relate to procedures in the cellular core network rather than the air interface: *call management*, *data transmission*, *location*, *network*, and *security*.

### 7.2.4. Technical categories of the patent families in the study

There are 210 patent families in the Fairfield LTE/SAE study of which 166 were declared essential to LTE and 44 were declared essential to SAE. However, every one of these patent families was reviewed for essentiality to both standards<sup>21</sup>. All of the patents declared essential to SAE are assigned to Nokia Corporation.

We studied the “family member first reviewed” of each of the 210 families and assigned each patent to one or more technology categories that were identified in the 2006 Fairfield study of patents declared essential to WCDMA. 176 of the 210 patents disclose technology in a single technical category. Of the 33 patents covering technology in more than one category, 15 patents claim MIMO (multiple input multiple output) technology, primarily in the antenna category.

### 7.2.5. Technical categories of the patents declared essential

The 210 families span 13 of the 17 technical categories in the 2006 Fairfield WCDMA study. Of these, the seven categories related to the air interface between base stations and wireless terminals dominate the study. They cover 148 of the 209 patent families as follows: Layer 2 (41 families), radio resources (29), antenna (23), radio signals (20), source coding (16), handover (14), and channel coding (5).

#### 7.2.5.1 Details of patent families covering the layer 2 and antenna categories.

One purpose of layer 2 (data link layer) in a data transmission system is to organize the ones and zeros transmitted in the physical layer (layer 1) into data units. Each data unit contains redundant bits that enable a receiver to determine whether the data unit has been received correctly. Of the 41 patent families in the layer 2 category, 17 patents claim ARQ techniques used when a receiver detects transmission errors. In addition, 12 patent families in the layer 2 category claim MAC techniques, which contain rules determining when a terminal or a base station is allowed to transmit a data unit. All but one of the 23 patents in the antenna category relate to MIMO operation.

---

<sup>21</sup> Since our reviewers stopped analyzing a family once one patent was found essential to one standard, no patent or family was found essential to both LTE and SAE standards.

### 7.2.5.2 Details of patent families covering the data transmission category

The data transmission category includes technology that can be used in a variety of networking environments in addition to wireless communications. One aspect of data transmission technology that has received a lot of attention in the LTE/SAE study is *header compression*. In addition to the “payload” each data unit in a data transmission system contains a “header”. Information in the header helps the network move the payload from its source to the destination. Examples of header information are addresses and time stamps. System efficiency can be compromised if the size of the header is large relative to the size of the payload. Header compression techniques allow a system to transmit headers that are smaller than the headers used by the source and destination devices. Compression is followed by transmission and then by decompression to restore the header to its original form.

Thirteen of the 18 patents families in the data transmission category disclose header compression techniques. All of these 13 patents have been declared essential to LTE.

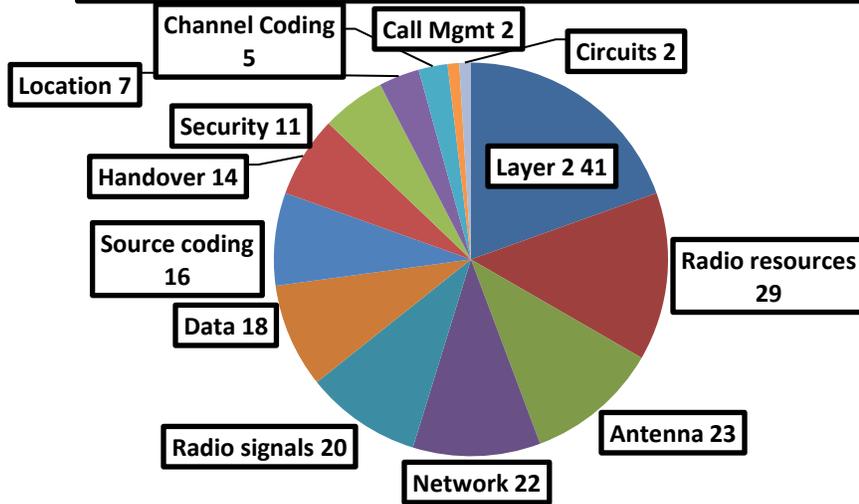
### 7.2.5.3 Technical categories of patents declared essential to SAE

The 44 patent families declared essential to SAE, all by Nokia, contain a large majority of all the patent families in the *network* category (20 of 22), a large majority of all the patent families in the *security* category (9 of 11) and a large majority of all the patent families in the *location* category (6 of 7). The other nine patents declared essential to SAE are distributed among five categories.

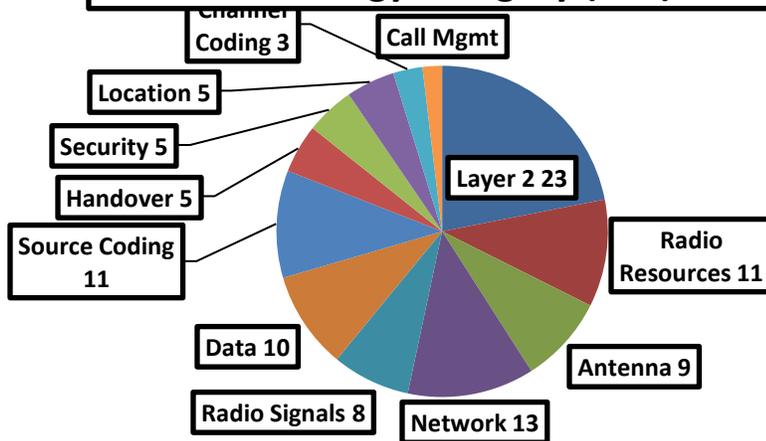
### 7.2.5.4 Summary of technical category statistics

|                     | <b>Total Families in Category</b> | <b>Families with at least one Patent Judged E/E*</b> |
|---------------------|-----------------------------------|--|
| Layer 2             | 41                                | 23   |
| Radio resources     | 29                                | 11   |
| Antenna             | 23                                | 9  |
| Network             | 22                                | 13   |
| Radio signals       | 20                                | 8  |
| Data transmission   | 18                                | 10   |
| Source coding       | 16                                | 11   |
| Handover            | 14                                | 5  |
| Security            | 11                                | 5  |
| Location            | 7                                 | 5  |
| Channel Coding      | 5                                 | 3  |
| Call Management     | 2                                 | 2  |
| Electronic circuits | 2                                 | 0  |
| <b>Total</b>        | <b>210</b>                        | <b>105</b>   |

### Families Declared as Essential to LTE/SAE by Technology Category (210)



### Families Judged Essential to LTE/SAE by Technology Category (105)



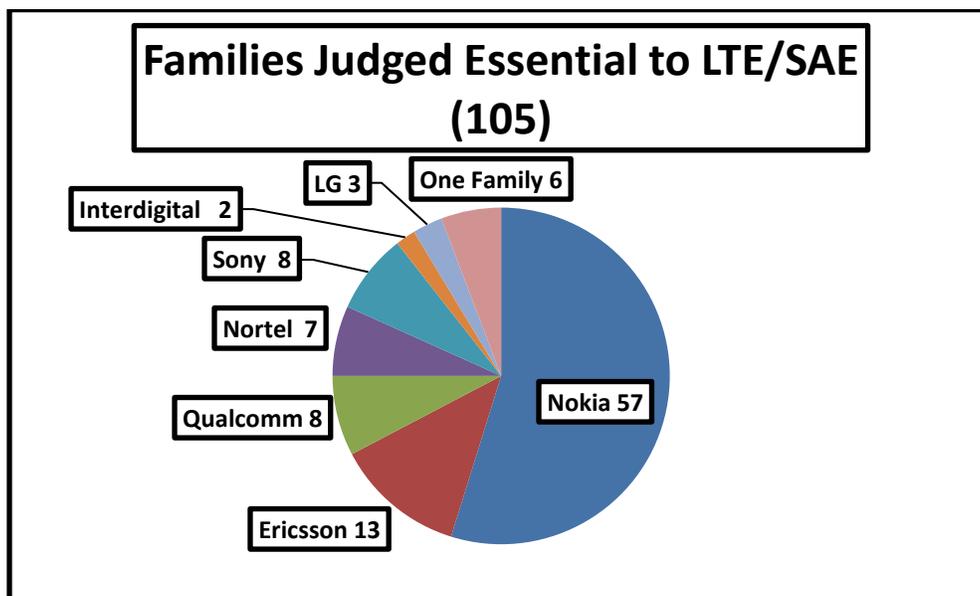
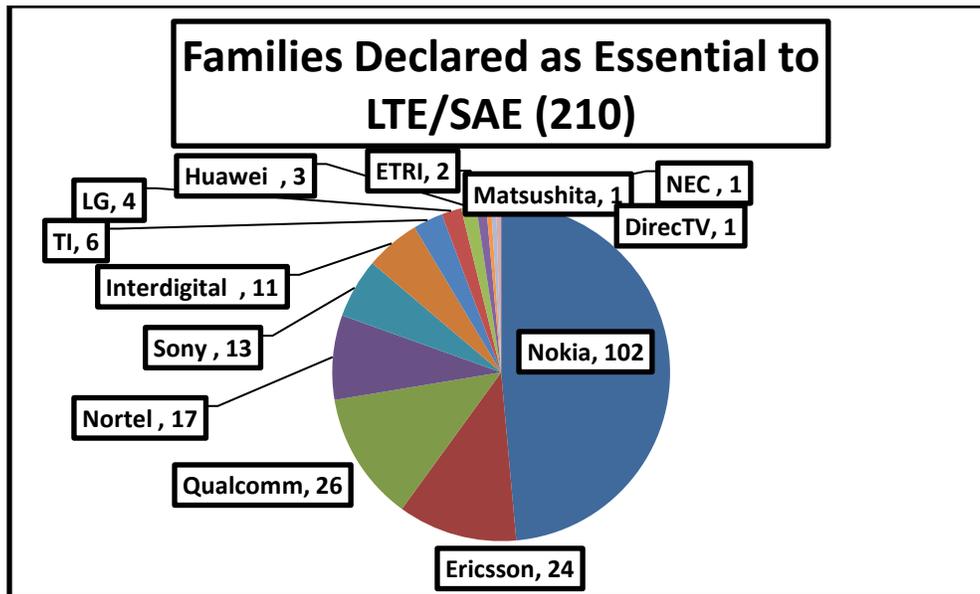
## 8. Patent ownership

The 210 patent families in the study are assigned to 13 different organizations: 11 companies, Sherbrooke University, and ETRI (Electronics and Telecommunications Research Institute). Nokia dominates the study with 102 declared patent families, 48% of the total. (Nokia also owns rights to the Sherbrooke patents<sup>22</sup> and we have consistently included those patents in the Nokia totals.) Almost half of the other 108 patent families are assigned to Qualcomm (26 families, 12%) and Ericsson (24 families, 11%). These numbers are shown in the next table and pie charts, which also include the number of families with a patent judged essential.

|                  | <b>Total Families Declared</b> | <b>Families with a Patent Judged E/E*</b> |
|------------------|--------------------------------|---|
| Nokia            | 102                            | 57  |
| Qualcomm         | 26                             | 8   |
| Ericsson         | 24                             | 14  |
| Nortel Networks  | 17                             | 7   |
| Sony Corporation | 12                             | 8   |
| Interdigital     | 11                             | 2   |
| TI               | 6                              | 1   |
| LG               | 4                              | 3   |
| Huawei           | 3                              | 1   |
| ETRI             | 2                              | 1   |
| Matsushita       | 1                              | 1   |
| NEC              | 1                              | 1   |
| Alcatel          | 1                              | 0   |
| DirecTV          | 1                              | 1   |
| <b>Totals</b>    | <b>210</b>                     | <b>105</b>                                |

---

<sup>22</sup> We have previously judged these patents as essential to WCDMA.



## 9. Relation to earlier studies

It is instructive to compare the technology categories in the Fairfield LTE/SAE study with those reported in earlier Fairfield studies of patents declared essential to cellular

technologies. In 2006 Fairfield reported the results of two 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 those studies, 68% of the declared patent families were in air interface categories, very similar to the 72% (152 patent families in a total of 210) in the LTE/SAE study.

In 2009 Fairfield reported on 369 patent families declared essential to WCDMA between the beginning of 2006 and the end of 2008. In the 2009 report, only 48% of the patent families covered air interface technologies. The majority of patent families claimed procedures in the cellular core network with the largest number (31%) in the network category. This shift reflects the fact that major thrusts of innovation in the second half of the 2000 decade have been to bring cellular core networks in line with the Internet and to introduce new services. As we stated earlier, LTE introduces two new air interfaces based on FDMA and the distribution of patent categories in this report reflects the volume of innovation needed to establish effective standards for operation of the air interface.

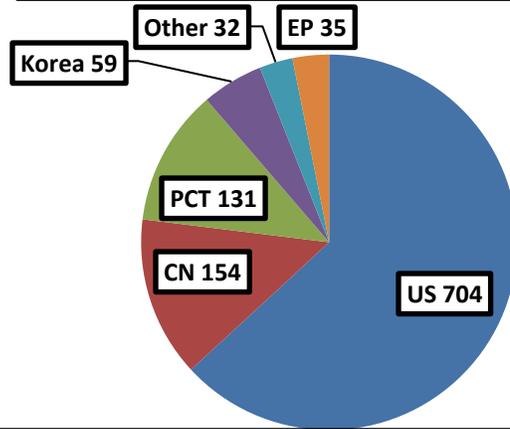
## **10. Forthcoming Patents Declared as Essential to LTE and SAE**

The primary purpose of this study was to judge the essentiality of issued patents which have been declared as essential to LTE and SAE. However, it is clear that the 210 families with an issued US, EP or CN patent on which we report here are only an indication of what we can expect in the future. The patents we reviewed were not even 20% of the 1115 patents and applications recorded on the ETSI web site<sup>23</sup>. The following chart and table show the jurisdiction and assignees of all of the declared patents and applications, where 59 of the “other” declarations in the table are Korean applications.

---

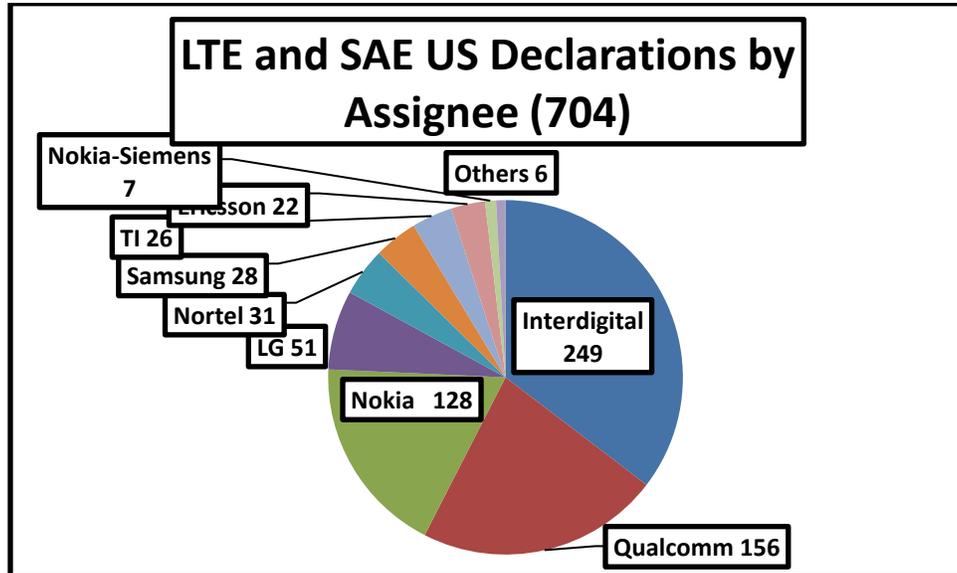
<sup>23</sup> <http://webapp.etsi.org/IPR/>

### LTE and SAE Declarations by Jurisdiction (1115)



|                | US         | CN         | PCT        | EP        | Other     | All Declarations |
|----------------|------------|------------|------------|-----------|-----------|------------------|
| Interdigital   | 249        |            |            |           |           | 249              |
| Nokia          | 128        |            | 25         | 12        | 2         | 167              |
| Qualcomm       | 156        |            | 9          | 1         |           | 166              |
| Huawei         |            | 143        | 4          |           |           | 147              |
| LG             | 51         |            | 40         |           | 1         | 92               |
| Samsung        | 28         | 9          |            |           | 27        | 64               |
| Ericsson       | 22         |            | 25         |           |           | 47               |
| Nortel         | 31         |            |            | 7         | 7         | 45               |
| ETRI           | 2          |            |            |           | 33        | 35               |
| Nokia-Siemens  | 7          |            | 11         | 3         | 10        | 31               |
| TI             | 26         |            |            |           |           | 26               |
| NEC            |            |            | 13         |           | 6         | 19               |
| Sony           | 3          |            |            | 9         |           | 12               |
| T-Mobile       |            |            | 2          | 3         |           | 5                |
| Alcatel-Lucent |            | 2          | 2          |           |           | 4                |
| Infineon       |            |            |            |           | 2         | 2                |
| Freescall      |            |            |            |           | 1         | 1                |
| Gemplus        |            |            |            |           | 1         | 1                |
| iCera          |            |            |            |           | 1         | 1                |
| iCoding        | 1          |            |            |           |           | 1                |
| <b>Total</b>   | <b>704</b> | <b>154</b> | <b>131</b> | <b>35</b> | <b>91</b> | <b>1115</b>      |

Naturally, there are likely to be declarations of the same invention in several jurisdictions (e.g., US, PCT<sup>24</sup>, EP and CN) so a more focused view of how many patent families we can expect to see in the near future is obtained by examining only a single jurisdiction. The following chart shows the distribution of US declarations by assignee. Clearly, Interdigital, Qualcomm, and Nokia have a great many potential patents in the pipeline. Note that Huawei at this time has no pending US applications.



We can estimate the number of future families with an issued patent from this total of 704 declared US patents and applications. Approximately 200 have issued to date, and about 50 of the declarations are abandoned provisional applications. That leaves about 450 pending US applications which have been declared as essential. Although not all of these will issue, and there are certainly several declared applications which are in the same family, it seems probable that there are as many as 400 additional patent families which may have an essential patent.

## 11. Limitations of this Research

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<sup>25</sup> and, subsequently, to LTE or SAE. Patents that

<sup>24</sup> PCT – Patent Cooperation Treaty

<sup>25</sup> For example, the speech-related standards for GSM and WCDMA are very similar; in some cases, identical.

were declared to ETSI as essential to these 2G and 3G standards were not included in the results reported here unless they were also declared as essential to the 4G standards (LTE or SAE).

Several standards offer optional approaches to meeting their requirements -- for example, MIMO is an optional implementation. Our reviewers found thirteen patents (and, hence, their families) which are, in their opinion, essential to an optional element of a standard such as MIMO. In our opinion, it is appropriate to include all of these families as essential or probably essential which is what we have done<sup>26</sup>.

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 would take into account agreements that transfer patent rights from the company identified on the patent to another company<sup>27</sup>.

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<sup>28</sup>.

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. Even though some of the claims in patents that were judged essential are extremely broad, the experts did *not* assess their validity.

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. Fairfield took great pains to identify declared patent applications which subsequently issued before July 1, 2009. 3GPP continues 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 July 1, 2009 may be found to be essential to specifications to be published in the

---

<sup>26</sup> These patents are all properly identified in the spreadsheets detailing our results, should a different choice be deemed preferable.

<sup>27</sup> As we did, for example, for the Sherbrooke University patents controlled by Nokia.

<sup>28</sup> Spending many hours or days reviewing each one of over 200 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.

future<sup>29</sup>. The large percentage 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.

---

<sup>29</sup> Several of the rationales provided by our experts mention that the section of the standard to which the patent might be essential is currently under consideration, but is not part of Release 8.0.

## **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 TRANSMISSION

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).

### HANDOVER

Transferring a communication from one antenna in the fixed part of the radio access network to another. Some patents in this category relate to the situation in which the original antenna and the new antenna transmit signals with different technologies (for example WCDMA and LTE).

### 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 this 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 terminal, the network has to know which base station the terminal is in contact with. To make this possible, an inactive terminal from time to time sends a registration message to the network. When the network has to set up communication, it pages the terminal at base stations near the one that received the latest registration message. The patents also disclose technology for determining the geographical coordinates of a wireless device. Several patents in the Location category 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).

## RADIO SIGNALS

These patents cover the signals transmitted between terminals and base station including modulation techniques that transform the ones and zeros into radio signals to be transmitted at specified frequencies.

## RADIO RESOURCES

The patents in this category claim techniques for efficiently managing transmitter power levels and data rates of the signals that share the same radio spectrum. Some of them claim techniques for channel quality estimation that enable the system to adapt the modulation and coding schemes to current channel conditions.

## SECURITY

Encryption of information to prevent eavesdropping. Authentication to ensure that only authorized users have access to networks or specific types of information (such as the location of a mobile device).

## SOURCE CODING

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