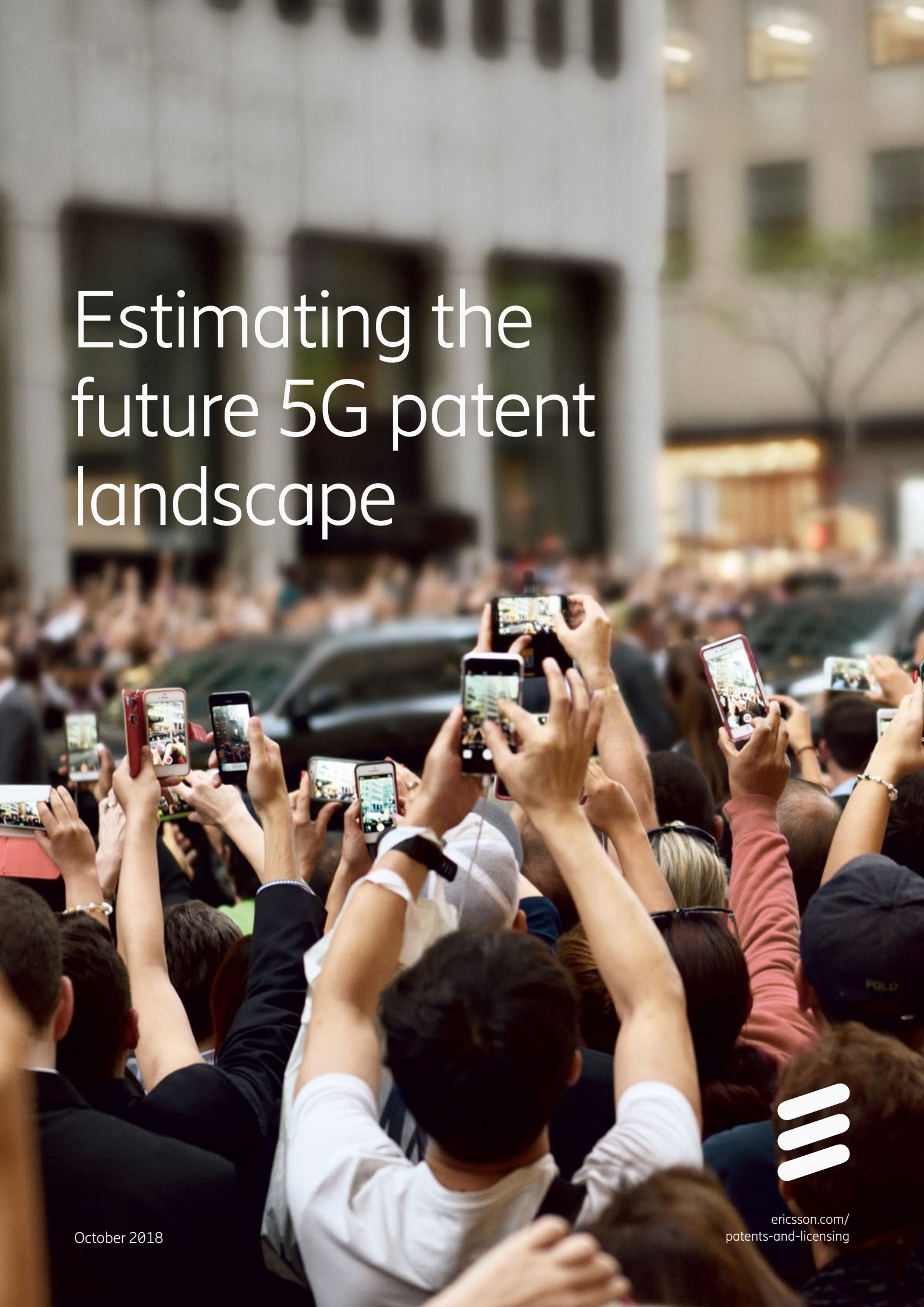
Estimating the future 5G patent landscape



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Introduction

Recent publications in popular news outlets indicate a growing interest around who owns the most significant 5G patent portfolios in the industry. Unfortunately, the vast majority of 5G patents have not yet issued from patent offices. They are still pending full examination of the merits, and many are not yet public. Thus, it is impossible to canvass the actual 5G patent landscape at this time. For portfolio evaluation purposes, comprehensive patent-by-patent analyses can only be done when the main portion of the potential 5G patents have been granted, which we expect will be several years from now.

An alternative approach to get an idea of the importance of different companies' future 5G patent portfolios is to analyze how much industry participants have contributed to the standard so far. The 5G standards are specified in 3GPP, and this data is public and readily available. The approach is therefore objective and repeatable by anyone. It builds on the plausible assumption that those companies with the most significant impact on the 5G standard will hold the strongest 5G patent portfolios going forward. The results show that Ericsson is the leading contributor to 3GPP.

Estimating 5G patent portfolio strength

The future 5G patent landscape can be estimated by analyzing companies' impact on the standardized 5G technology.

There is a growing interest in learning about the future patent landscape for 5G. The first revision of the standard specifications defining the technology for standalone 5G was approved in June 2018, and the whole industry is now on a final sprint to commercialize 5G.

Thus, over the past six months or so, media articles have started speculating about the number of patents different companies hold for 5G.

Regulators and policy-makers are also calling for greater transparency of the 5G patent and licensing landscape.[1] Some have expressed concerns that it is difficult for small and medium-sized enterprises (SMEs) that require licenses to 5G essential patents to know the ownership and pricing of the most significant 5G patent portfolios.

However, it is not yet possible to reliably estimate the future 5G patent landscape based on patent analysis as it takes years for a patent office to examine an application and issue a granted patent.[2] Furthermore, industry participants need to know the actual scope of protection of an issued patent to determine whether that patent is essential to 5G. At this point in time, a substantial portion of patent applications recently filed during 5G development are not yet granted, and many applications related to 5G are not yet even publicly available for analysis.

[1] European Commission, COM (2017) 712 final, "Setting out the EU approach to Standard Essential Patents" (November 2017).

[2] After submitting a patent application, it typically takes about one to three years to get a grant, sometimes significantly longer. It is also common for companies to submit provisional applications early, up to a year prior to submitting the corresponding patent application. This may add another year to the granting process. It is also common to file additional divisional/continuing applications several years after the original filing. This means it can take several years before the final protection scope is known, and the time may vary significantly.

An additional complexity is that the analysis of potentially essential patents is far from trivial. It requires detailed knowledge of patents and the regulatory environment in which they are granted, in addition to a deep understanding of intricate technical details and requirements set by 5G specifications. Portfolio valuation through essentiality analyses also requires knowledge of which portions of the standard are implemented by products in the market. A patent that is essential to a portion of a standard that has not been implemented at all is clearly not as relevant, even if it reads on the letters written in the standard document. For 5G, there is still not much information available regarding which standardized features will find traction in the market and be implemented in the future.

An invention is regularly filed in many countries, with multiple claims in each application, whereby the protection scope may differ between the different countries where the patents, derived from the invention, are filed. These patents, based on the same invention and filed in different countries, form a patent family.[3] In our experience, it takes tens of hours to reliably evaluate the potential essentiality of a single patent family, even for highly specialized experts in the corresponding technology. Such work is commonly conducted, e.g., during bilateral licensing discussions, when parties analyze selected portions (samples) of their respective portfolios. However, conducting a similar analysis of the full patent landscape for all potentially essential patent families is an overwhelming task that simply cannot be reliably conducted today, as many of the future 5G patents to be analyzed are not yet available for analysis.

An often-used starting point for essentiality analysis is the ETSI database, where contributors to 3GPP submit their declarations of what may be or may become essential for a standard developed by 3GPP. Some companies have already made such "5G declarations".[4] However, only after all contributors to 3GPP submit their 5G declarations and the 5G patents in the declared patent families are granted can industry participants analyze those patents for essentiality.

When analyzing the ETSI declarations made to 5G projects through early June 2018 and correlating these declarations to patent databases, it turns out that only a subset of the declarations can yet be associated with publicly available patent families, see Figure 1. Before this ETSI data on 5G can be used for any meaningful analysis, at a minimum, the declared families must become public, and patents from those declared families must issue. Until then, the ETSI database simply cannot act as a reliable starting point for 5G analysis.

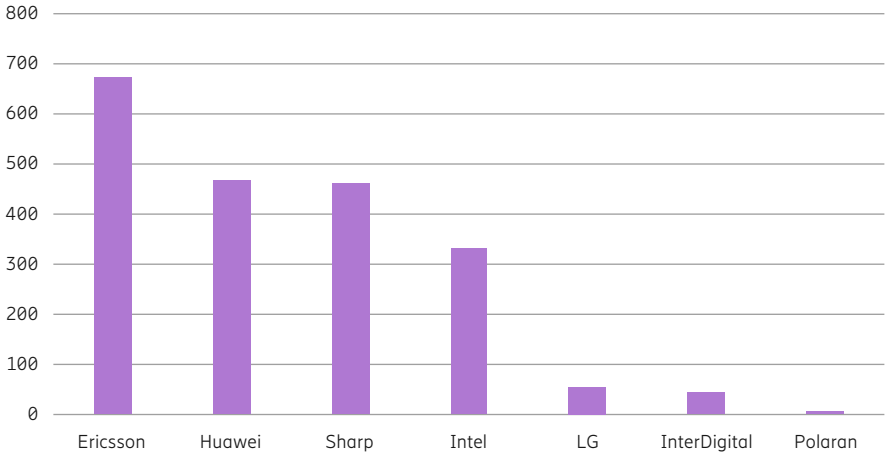
Analyzing 3GPP impact

Another approach for estimating future 5G patent portfolio strength is to analyze the impact that companies have made on the development of the 5G standard. This approach builds on the plausible assumption that those companies with the most significant impact on the 5G standard will have the strongest 5G patent portfolios going forward.

Development of the 5G standard is being done in 3GPP, a partnership of standards development organizations from around the world that have defined the 3G, 4G and now 5G standards. Its members include numerous telecommunications companies, including Ericsson, Nokia, Qualcomm, Samsung, Huawei and many others. 3GPP is contribution-driven, which means that member companies submit technical proposals for inclusion in the standard. Alternative solutions are often proposed by multiple 3GPP members, followed by enhancements and compromises. The resulting solutions that end up in the standard have thus been vetted and scrutinized by experts from many companies that often are competitors in the marketplace. 3GPP is therefore both a collaborative and highly competitive forum.

Developing technically meaningful and convincing contributions requires significant research efforts and investments, and the competitive nature of 3GPP means that, to be taken seriously, careful analysis of the benefits and drawbacks of proposals needs to be undertaken.

Figure 1: Publicly available patent families associated with 5G declarations by June 2018[5]



Note: Number of publicly available patent families associated with 5G declarations by early June 2018. At the time of analysis, Ericsson had made close to 1,200 5G declarations, but less than 700 were available publicly. Since then, Ericsson has provided further 5G declarations to ETSI. With regard to the industry as a whole, we found 6,295 5G declarations from 13 companies in total, but only 2,041 publicly available patent families associated with the declarations.

[3] The applications and patents originating from the same invention are said to belong to the same patent family. Some variations to the definition of a patent family exist.
[4] We use this term to denote the disclosure of one application or patent to ETSI according to the ETSI policy.
[5] Data in Figure 1 was compiled by Pattern, which is Bird & Bird LLP's patent intelligence offering. www.twobirds.com/en/client-solutions/consulting/pattern.

Meaningful participation in the 3GPP standards development requires long-term investments and thousands of R&D man-hours. Companies gain trust and credibility in 3GPP through long-term participation and by consistently working towards developing the best specifications.

Analyzing the impact of companies on the development of 3GPP standards has many attractive features as a proxy for future patent portfolio strength:

— 3GPP documents are public and accessible online for anyone to analyze. Also, 3GPP uploads documents on its website on a running basis, which means that trends and changes in impact can be observed in 3GPP much before any corresponding analyses can be done on patents in patent databases.
— 3GPP results are objective and transparent. Anyone can re-do the analysis and arrive at comparable results. This is different from any patent essentiality analysis, which requires significant input from technical and legal experts and cannot be easily checked or reproduced.
— Full view of all contributors. A 3GPP analysis gives a comprehensive picture of all contributors to the 3GPP technologies.

While there are many benefits with a 3GPP impact analysis, 3GPP landscaping has its potential uncertainties. It assumes that sophisticated companies have similar strategies of filing patents before they propose and drive their technology into 3GPP specifications. We believe that this is highly likely among sophisticated companies, as companies are generally incentivized to secure patents on their inventive technological advancements. Moreover, we have observed in past cross-licensing negotiations that companies do, in fact, patent their inventive contributions to 3GPP.

3GPP landscaping also assumes that only those contributing to 3GPP will have a significant essential patent portfolio.[6] We believe that this is also a valid assumption. It seems implausible that anyone not taking a strong responsibility for driving the development and evolution of the 3GPP standardized technology could develop a significant portfolio of essential patents. Our experience as a licensee has validated this assumption as well.

A third assumption is that the nature of contributions made to 3GPP is similar across companies. While it's theoretically possible for some companies to make small contributions and others to make large contributions, looking over a long period of time and thousands of contributions, it's unlikely that the lower-quality contributors could continue such a pattern. Those companies would likely begin to suffer reputational harm by consistently proposing immaterial contributions on a massive scale over an extended period of time. If they would then tout contributions as a proxy for patent portfolio strength, their later-issuing patent portfolios would be disproportionately weak compared to other patent holders, further damaging their reputation. So, while this third assumption could be affected by short-term opportunism, it's likely to hold across longer timescales. Also, reputation could be cross-checked by observing other 3GPP behavior, such as whether large contributors are (or are not) being elected or appointed to leadership positions. In this regard, Ericsson currently holds the most chairmanships and vice chairman positions in 3GPP.

The companies contributing most to the standards development are expected to have the most significant standard essential patent portfolios.

Ericsson is both a licensor of essential patents and a licensee, with billions of dollars of global sales of cellular infrastructure equipment. Our experience in numerous licensing discussions is that impact on the development of 3GPP standards correlates well with relative patent portfolio strength. Thus, 3GPP impact is a good leading indicator of patent portfolio strength and, at this point in time, the best and most reliable method available for estimating future patent portfolio strength. The companies contributing most to the standards development are expected to have the most significant standard essential patent portfolios.

[6] 3GPP landscaping is particularly informative for large contributors with significant portfolios. For minor contributors and holders of only a few patents, the landscaping can be less accurate.

The 3GPP landscape

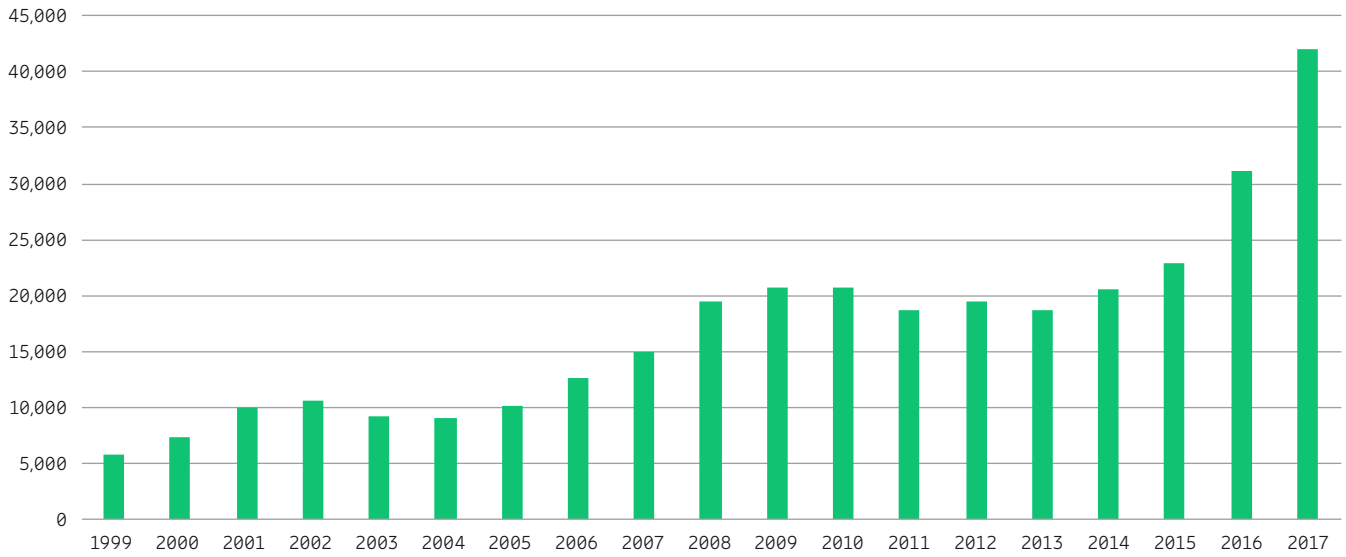
3GPP standardizes new technologies based on input from its members. Member contributions have grown tremendously over time.

Since its original scope in the late 1990s to produce technical specifications for 3G, 3GPP has evolved considerably. Today, 3GPP is responsible for the maintenance and evolution of 2G, 3G and 4G.[7] And with 5G, the 3GPP family of technologies now includes a fourth member.

The current 3GPP cellular technologies have been extraordinary successes, and the expectations for 5G are very high. While the original intent of 2G was primarily to serve voice communication, the latter technologies now serve a whole array of use cases at a performance level that even the most optimistic predictions 20 years back could not foresee. We now take it almost for granted that we have internet, music streaming, social connections, news, boarding passes, payment, banking, games and so on, available in our pocket – a futuristic scenario that few would have believed possible just a few years ago. The cellular technologies have enabled whole new industries, such as the app stores and companies developing the apps, and are transforming existing industries, such as automotive, to provide enhanced safety, efficiency, entertainment and other services.

The success of the 3GPP family of technologies is also reflected in the increased investments companies make in further developing improved technical solutions for standardization. Since its start in 1999, 3GPP has grown tremendously, and the total number of technical input papers has increased more than six-fold from slightly less than 6,000 in 1999 to more than 40,000 input papers in 2017, see Figure 2 below.

Figure 2: Number of technical 3GPP input papers per year



Note: Number of technical input papers submitted to 3GPP per year. Administrative documents and resubmitted duplicate input documents are not included.

[7] Each technology has undergone continuous improvements in 3GPP over the years, through new releases. Today, the activity to evolve 2G and 3G is limited, while both 4G and 5G will be subject to further improvements.

The sheer number illustrates the enormous efforts and activities that are undertaken by 3GPP members, which is also evident from the size of recent expert meetings. For example, RAN Working Group 1 ("RAN1", see below), which is responsible for the standardization of the physical air-interface layer, meets at least 8 times a year at various locations around the globe with up to 500 delegates attending each meeting. And RAN1 is just 1 out of 16 3GPP Working Groups that gather on a regular schedule, albeit a very important one. The current 3GPP Working Group organization is shown in Figure 3 below.

Figure 3: Technical Specification Groups structure in 3GPP

Project Co-ordination Group		
TSG RAN Radio Access Network	**TSG SA** Service & Systems Aspects	**TSG CT** Core Network & Terminals
RAN WG1 Radio Layer 1 spec	**SA WG1** Services	**CT WG1** MM/CC/SM(u)
RAN WG2 Radio Layer 2 spec Radio Layer 3 RR spec	**SA WG2** Architecture	**CT WG3** Interworking with external networks
RAN WG3 lub spec, lur spec, lu spec UTRAN O&M requirements	**SA WG3** Security	**CT WG4** MAP/GTP/BCH/SS
RAN WG4 Radio Performance Protocol aspects	**SA WG4** Codec	**CT WG6** Smart Card Application Aspects
RAN WG5 Mobile Terminal Conformance Testing	**SA WG5** Telecom Management	
RAN WG6 Legacy RAN radio and protocol	**SA WG6** Mission-critical applications	

Note: The technical work in 3GPP is subdivided into 3 Technical Specification Groups and further into 16 Working Groups that have development responsibilities for specific functions and standard documents.[8]

The sophistication and breadth of the technology has increased and the competition between contributors has turned fiercer. Today, companies must invest significantly more to keep up with the pace in 3GPP. This is a sign of the success of 3GPP standardization and the value of the technology described in the standards. 3GPP has welcomed new contributors that were not there from the start (e.g., Huawei, Intel, Qualcomm, Samsung), other members have disappeared for various reasons (e.g., Nortel, Siemens), while some have maintained a significant role throughout the history of 3GPP (e.g., Ericsson, Nokia).

In short, the amount of technology contributed to 3GPP has grown significantly over the years.

[8] 3GPP, "Specification Groups", www.3gpp.org/specifications-groups (Accessed October 2018).

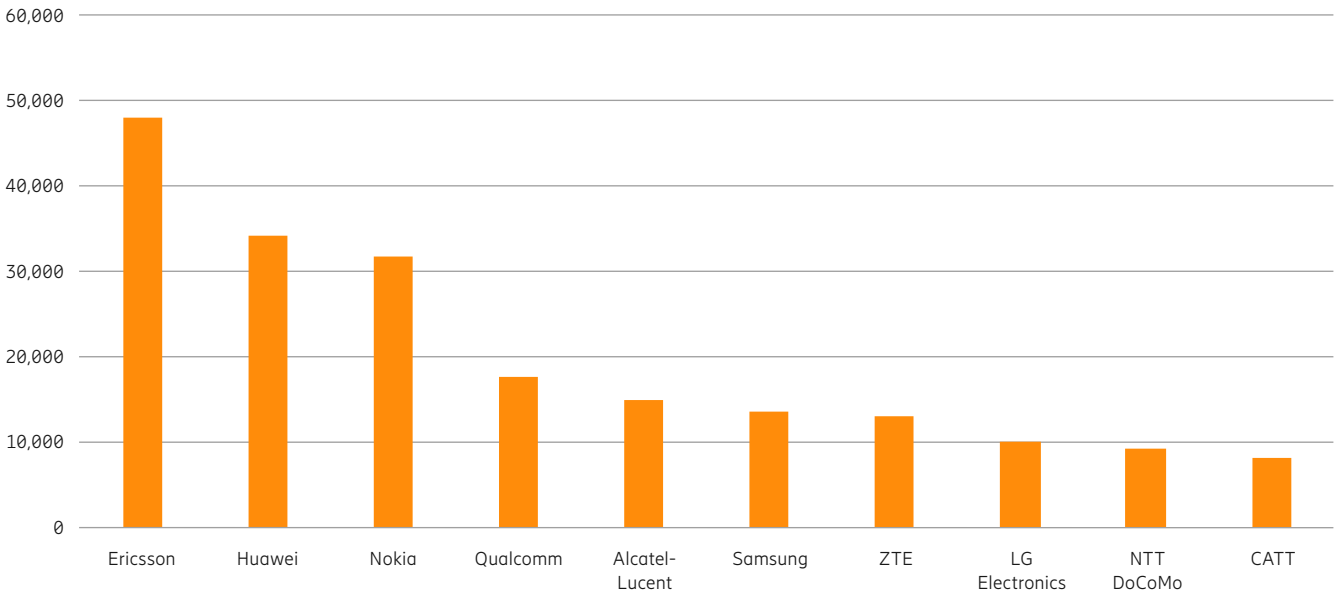
Who are the leading contributors to the 3GPP standards?

Leading contributors will likely have the strongest 5G patent portfolios.

In Figure 4, the number of submitted technical papers to 3GPP per company since 1999 to 2017 are shown. The statistics include all 3GPP Working Groups; today there are 16 Working Groups that focus on different technical areas and carry responsibility for different interfaces (see Figure 3).

As can be seen from Figure 4, Ericsson is the company that has taken the strongest responsibility of specification development in 3GPP, followed by Huawei, Nokia, Qualcomm, Alcatel-Lucent and Samsung.

Figure 4: Total number of submitted technical papers to 3GPP, 1999–2017



Note: Technical input papers per company submitted to 3GPP, across all Working Groups, counting only the first listed source of a contribution. Alcatel-Lucent was merged into Nokia in 2016. Adding Alcatel-Lucent's submitted contributions to Nokia would place Nokia in second place after Ericsson.

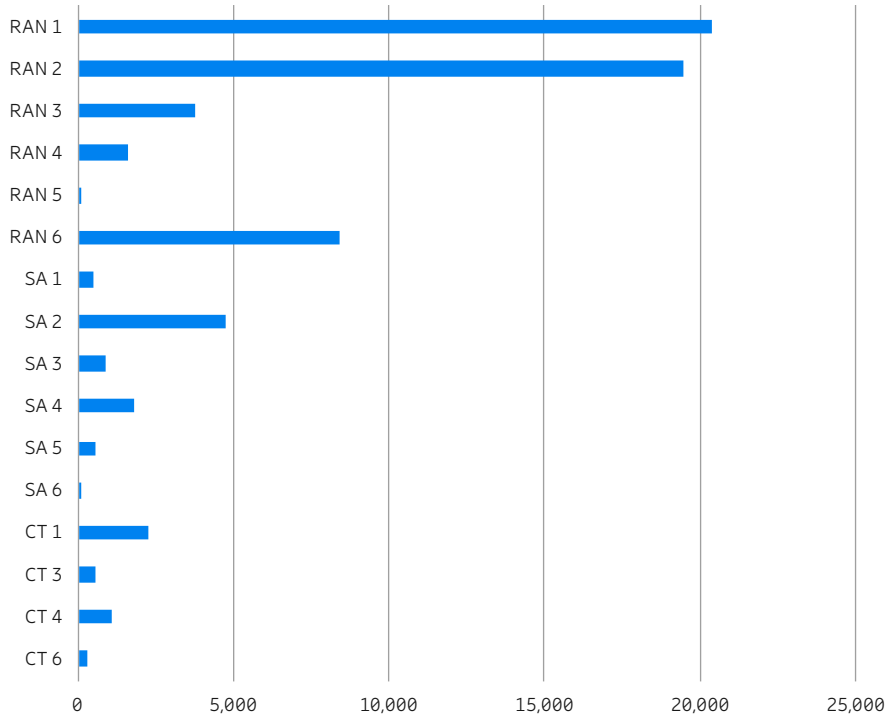
However, not all Working Groups are equally relevant from an IPR perspective. In some Working Groups, the work often results in standardizing technology enhancements that are patentable and drive consumer demand. In other groups, the focus areas less often result in any standard-essential patents. An example of the latter is RAN5 (RAN WG5), which focuses on conformance testing. While the work in RAN5 is very important for worldwide interoperability and conformance, it seldom results in any standard-essential patents.

One way to identify the Working Groups that have the highest bearing on IPR is to consult the ETSI IPR declaration database, where patent owners declare the patent families they believe themselves may include (or may include in the future) a protection scope that is required by the specifications. Those declarations frequently also include references to the specifications that the declarant believes may include the declared IPR, see Figure 5.

These statistics are taken over all ETSI declarations. The figure shows unambiguously the importance of RAN1 and RAN2 (RAN WG1 and WG2), as companies believe their IPR may predominantly read on the specifications produced by these two Working Groups. RAN1 and RAN2 are engaged in the standardization of the interfaces and technology required over the air between the mobile device and the network infrastructure.

RAN6 has a high score as well. This is because RAN6 has maintained 2G and 3G radio protocols since 2016. RAN6 took over responsibility of e.g., the 3G specifications that RAN1 and RAN2 had developed and evolved since 1999.

Figure 5: Number of citations in ETSI declarations related to 3GPP Working Groups[11]



Note: The figure illustrates the Working Groups responsible for the specifications that IPR declarants have referred to in their ETSI declarations. One count is given for each reference[9], and the figure gives a relative measure of where essential IPR is likely to be found.

Thus, the high RAN6 score in the figure above mainly includes older declarations (prior to 2016) originally associated with RAN1 and RAN2, before those groups handed the specifications over to RAN6 for maintenance. Thus, landscaping of RAN1 and RAN2 since 1999 would capture the 3G activity related to declarations now associated with RAN6[10] and this for the period between 1999 and 2016.

Further, one needs to consider which Working Groups are relevant for a particular product category. For example, RAN3 is associated with a fair share of ETSI declarations in the figure above, but the RAN3 work has no relevance for consumer devices, such as mobile phones. Instead, RAN3 is responsible for interfaces between infrastructure equipment. RAN3 should therefore be considered only if one wants to check the impact of companies on these interface solutions between infrastructure equipment.

[9] Not all declarations include a reference, and some include multiple. The same family may also be essential to multiple technologies, such as 4G and 5G, in which case the family may have been declared multiple times.
[10] The activity level in RAN6 is very limited today, with less than 20 delegates attending recent meetings. In comparison, RAN1 and RAN2 meetings typically attract between 300 to 500 registered experts to each group and each meeting.
[11] Data in Figure 5 was compiled by Pattern, which is Bird & Bird LLP's patent intelligence offering. www.twobirds.com/en/client-solutions/consulting/pattern.

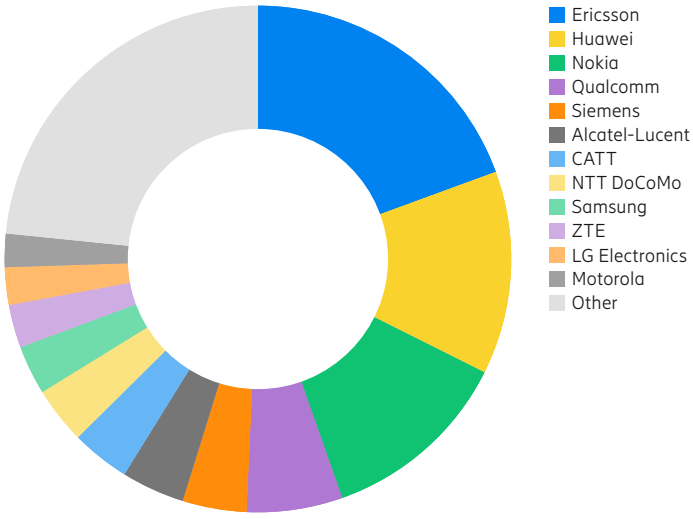
More specifically, a company that manufactures consumer devices, such as a handset or IoT device compliant with 3GPP specifications, does not need to implement the technology specified in the specifications within RAN3 responsibility. The same holds for multiple other groups, including SA5, CT3 and CT4, where the specifications under the responsibility of these groups have limited or no impact on consumer devices. While one should not underestimate the importance of the work in those groups – it's very important for the whole architecture to work, which benefits everyone – that work does not specifically relate to consumer device IPR.

It's significant to note here that Ericsson participates heavily across all 3GPP groups. Ericsson has the role of a lead architect which ensures that 3GPP technology as a whole interoperates properly. This role can only be performed by a company that is fully engaged in the standard development. In addition to RAN1 and RAN2, also RAN4, SA2, SA3, SA4 and CT1 define specifications with which consumer devices must comply. Except for SA4, we have included these various groups in our analysis. We excluded the SA4 Working Group, since SA4 works with codecs and it can be difficult to associate the SA4 work with a particular generation of cellular technology, such as 3G, 4G or 5G.[12] Further, codecs (e.g., for voice calls) are not necessarily required by all future 5G devices. Thus, we analyze six groups (RAN1, RAN2, RAN4, SA2, SA3 and CT1) to estimate the relative IPR portfolio strength related to consumer devices. We note that these six groups have also previously been included in similar studies by industry analysts Signals Research Group and ABI Research.

Analyzing approved papers

A compelling filter that can be added onto the 3GPP contribution data is to analyze approved contributions only. The underlying rationale is that only those submissions that are approved for inclusion into the specifications should be rewarded in the landscaping. Such results are shown in Figure 6 below, for the six Working Groups identified earlier, from 1999 until the end of 2017. The source data is filtered such that it includes papers identified as relevant for 3G, 4G and 5G access technologies. The agenda items of the meetings, under which the contributions are listed, are used for identifying the generation of technology to which each paper pertains. Papers related to, e.g., 2G, IMS, policy and charging, and network management are, as a consequence, excluded from the statistics shown in the figure below.

Figure 6: Multi-mode 3G, 4G, 5G share of approved contributions in six 3GPP Working Groups



Note: Portion of approved contributions to RAN1, RAN2, RAN4, CT1, SA2 and SA3 through the end of 2017. Ericsson has authored more than 19 percent of the approved contributions. In case of multiple sourcing companies, only the first sourcing company is given the credit for each approved contribution.

[12] Ericsson has also contributed significantly more than any other company in SA4.

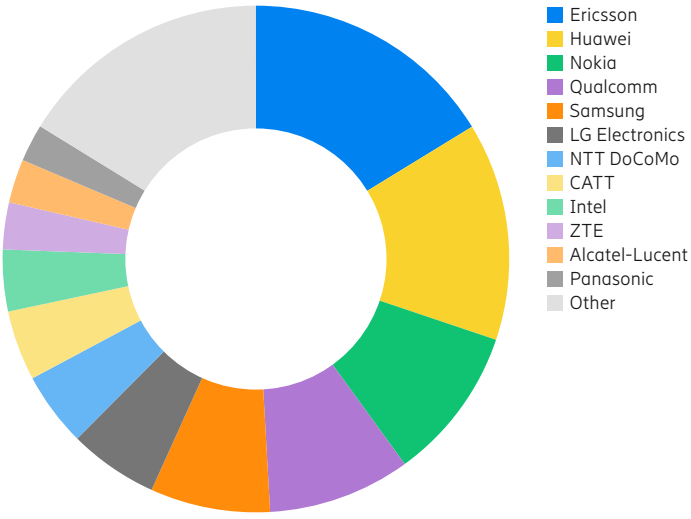
As can be seen in Figure 6, Ericsson is the 3GPP member that has contributed most to 3G, 4G and 5G combined between 1999 and 2017. Ericsson has contributed more than 19 percent of the approved submissions.

The statistics in Figure 6 include technical papers all the way back to 1999. We include this 20-year time horizon because, according to most jurisdictions, patents have a lifespan of 20 years. Moreover, a new generation of cellular technology does not appear in a vacuum. Some solutions that have been proven powerful in a previous generation are inherited by the next, with new performance-enhancing improvements and refinements added. This means that some patents that are essential for one generation will also be essential for the next generation, in addition to all the new inventions that have been discovered after the creation of the earlier generation of technology.

Narrowing the timescale

In Figure 7, we have narrowed the scope of these statistics in two ways. First, we have excluded 3G from the statistics, meaning that the relevant 3GPP data in practice now goes back to around 2006, when 4G standardization began. Comparing Figure 6 and Figure 7, it can be seen that limiting the time horizon by excluding 3G will lift some companies that have joined 3GPP later. And some companies that are seen in Figure 6 no longer exist or otherwise have left the 3GPP arena, vanishing from Figure 7 below. Secondly, we have limited Figure 7 to the two most relevant 3GPP Working Groups for 4G and 5G access technologies, namely RAN1 and RAN2. As can be seen here, Ericsson is still in the lead with more than 16 percent of all approved papers.

Figure 7: Multi-mode 4G, 5G share of approved contributions in RAN1 and RAN2

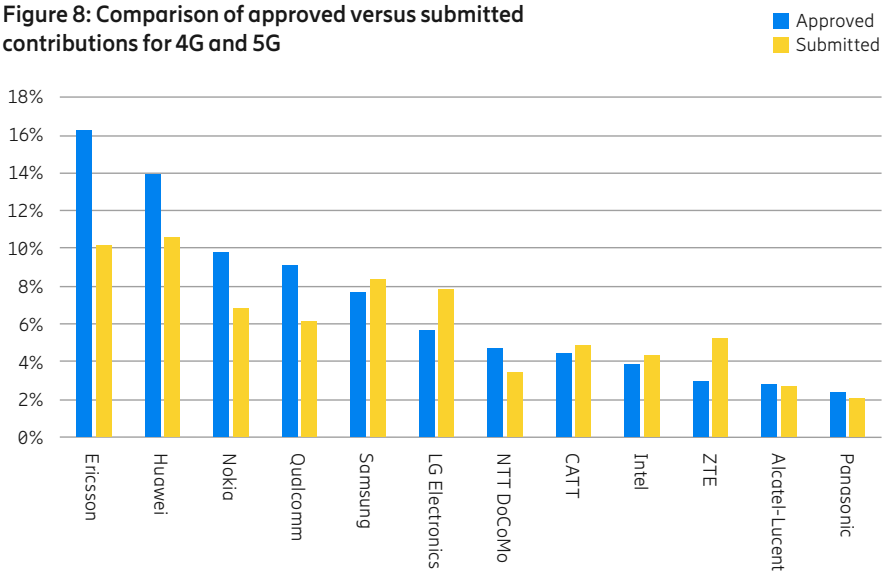


Note: Portion of approved contributions to RAN1 and RAN2 for multimode 4G/5G through the end of 2017. Ericsson is the first source in more than 16 percent of the papers. In case of multiple sourcing companies, only the first sourcing company is given the credit for each approved contribution.

Approved versus submitted papers

Analyzing the effect of counting approved contributions versus all submitted papers can be of interest. In the following, we have compared approved submissions (same as in Figure 7) with submitted contributions.[13] As can be seen in Figure 8, leading companies more often get a higher score when approved papers are considered.[14] One possible explanation for this could be that the technical input from leading companies is of better quality on average and therefore receives higher support at the meetings. This could be due to earlier and more substantial research and development of the technology by those leading companies, a broader understanding of the interrelationships among technology proposals across the entire technology architecture, or credibility and trust gained over the course of technology development. For some of the leading companies, such as Ericsson, the portion of approved papers is remarkably higher than the portion of submitted ones.

Figure 8: Comparison of approved versus submitted contributions for 4G and 5G

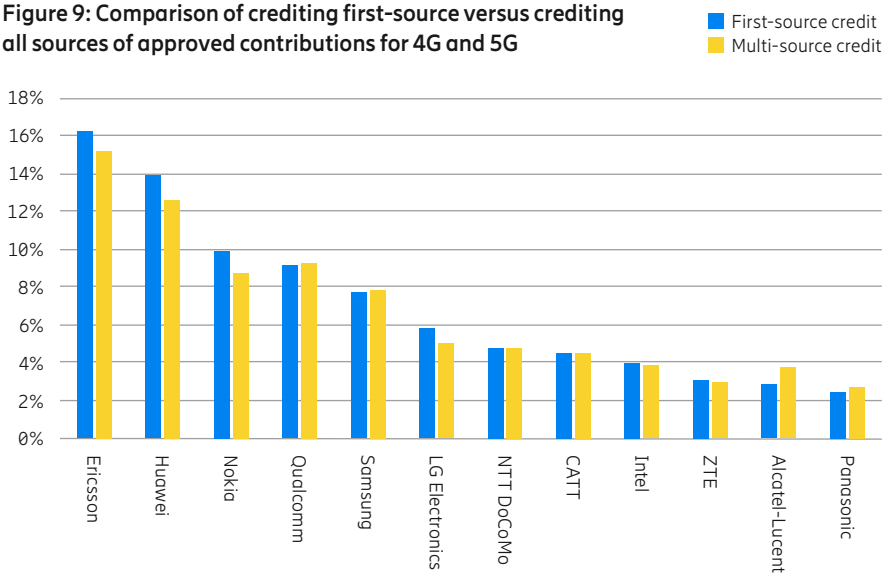


Note: Comparison of approved contributions versus submitted in RAN1 and RAN2, for 4G/5G multi-mode through the end of 2017. Leading contributors appear to have a higher acceptance rate than average. In case of multiple sourcing companies, only the first sourcing company is given the credit for each approved contribution.

Crediting all co-sourcing companies

Another issue is whether the first source of the paper should be given all credit, or if equal credit should be given to all co-sourcing companies.[15] One may expect that the latter option would favor followers at the expense of the first authors, since the collaborative character of 3GPP encourages companies to seek support through co-sourcing members that would endorse the proposal. This expectation is supported by the results in Figure 9, where we have done such a comparison. As seen here, leading companies generally appear slightly stronger when only the first-sourcing company is credited. This might be due to a possible trend where those in 3GPP who contribute less but follow the development closely are willing to co-sign the solutions they believe in. Such followers would be credited more with an approach that gives equal credit to all co-signers.

Figure 9: Comparison of crediting first-source versus crediting all sources of approved contributions for 4G and 5G



Note: Comparison between only crediting the first-sourcing company (as in previous figures) and crediting all contributing companies equally. The data is for approved contributions in RAN1 and RAN2 classified as relevant for 4G and 5G through the end of 2017.

[13] Submitted contributions include all technical input papers (excluding, e.g., duplicates, editor/rapporteur's updates and administrative documents) that each company has submitted to the concerned Working Group. Thus, submitted also includes approved.

[14] It is important to note that companies focused or specialized in a particular field that is being standardized by a particular Working Group (e.g., security features) can have even higher ratios of approved vs. non-approved submissions. However, the numbers considered in Figure 8 apply to the top contributing companies that are usually active in most of the Working Groups relevant to the current exercise. The leading companies are all active in multiple 3GPP Working Groups.

[15] Equal credit is given to each co-sourcing company by dividing one credit per approved paper among the co-sourcing companies. If there are three co-sourcing companies, each company is given one-third of a credit.

Analyzing 5G input papers in isolation

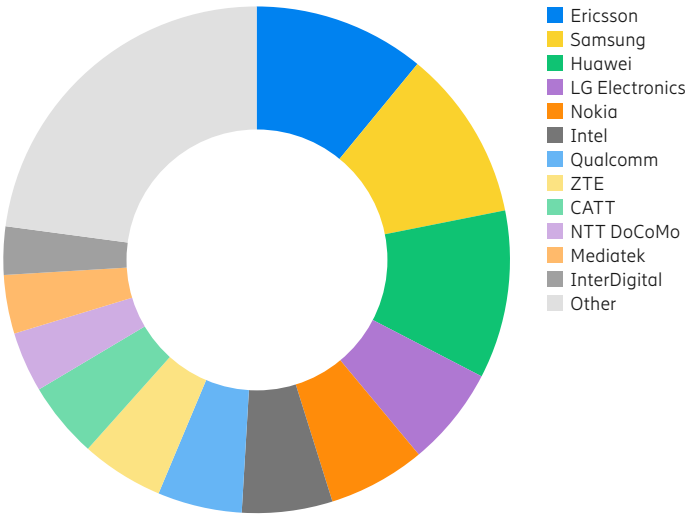
The next step in the analysis is to landscape the papers classified as 5G alone. Leaving out 4G from the analysis means that we in practice only measure 3GPP impact during the last two years, since papers classified as 5G began in greater numbers only from 2016 onwards. But 5G did not appear in a vacuum. Already in 2011, Ericsson started to lead the industry discussions around 5G, scoping out 5G services and requirements, and researching and developing the 5G technical concept.[16] In addition, 5G is based on some solutions already introduced in previous releases of the 4G specifications. Indeed, the first version of 5G, which was completed in December 2017,[17] is non-standalone 5G and is intended to work only in close conjunction with 4G through dual connectivity (also identified as NSA, EN-DC, or E-UTRA NR dual connectivity). So, while analyzing 5G alone can give some additional valuable insights, looking at aggregated 4G plus 5G statistics is still meaningful.

Also, in analyzing 5G alone, there is a challenge when considering the approval rate in RAN1 and RAN2. We know that the first intermediate solution of 5G, the non-standalone (NSA) version, was completed by 3GPP in December 2017. This was the result of tremendous efforts by participating companies, and the result of thousands of decisions made in the two Working Groups. However, the total number of approved contributions does not correlate well with the amount of work and the number of decisions made. In fact, while the papers classified as technical input to RAN1 and RAN2 for 5G add up to more than 17,000 in our statistics, the approved ones (after filtering away papers such as rapporteur or editor's updates, administrative documents, etc.) result in less than 200. One reason for the low number of approved papers is that these Working Groups have nowadays implemented work-procedures where company submissions are seldom approved as submitted. This is particularly true during early standard development, when the specifications are not yet under revision control. Instead, separate proposals in the papers are often endorsed by the Working Groups and then captured, e.g., by a work-item or specification rapporteur. This makes it harder to identify the origin of the included technology by landscaping the origin of approved papers.

As a consequence, below we have illustrated the landscape of the submitted papers, using the multi-source crediting method. This should give a conservative estimate of the expected 5G patent landscape of the leaders in 3GPP, since both the multi-sourcing approach and the landscaping of submitted papers (as opposed to approved) appear to underestimate the influence of leading companies.

As seen in Figure 10, Ericsson provided the most technical input documents by the end of 2017, followed closely by the next two companies. Since we analyzed input documents rather than approved documents, we expect that the leaders in 3GPP are in reality responsible for a higher fraction of the technology incorporated into the agreed standard (see Figure 8).

Figure 10: 5G single mode, share of submitted contributions in RAN1 and RAN2, all co-sourcing companies given equal credit



Note: Share of technical input documents to RAN1 and RAN2 related to 5G through the end of 2017. Each sourcing company is given equal credit. Ericsson provided the most technical input documents through the end of 2017, followed closely by the next two companies. Nokia and Alcatel-Lucent are here credited as a single entity.

[16] In May 2016, long before any significant number of 5G contributions started to appear in 3GPP, Ericsson filed its landmark 5G patent application – the largest patent application ever in cellular communications in terms of number of inventors (130). Thus, analyzing 5G contributions is informative, but one needs to appreciate that the 5G technology development was an ongoing effort initiated much before 2016 as an evolution over 4G.

[17] 3GPP, "First 5G NR Specs Approved", www.3gpp.org/news-events/3gpp-news/1929-nsa_nr_5g (Accessed September 2018).

Summary

In this report, we have analyzed the 3GPP landscape as a proxy for estimating 5G patent and technology leadership.

As of today, it is not yet possible to gain any trustworthy analysis of the future 5G patent landscape by analyzing patent declarations and patent databases alone. However, information about those impacting 3GPP standardization is already now readily available. It seems plausible that those companies that have had the most significant impact on the technology defined in the 3G, 4G and 5G specifications will also have the most significant patent portfolios. 3GPP impact is therefore a good leading indicator of patent portfolio strength.

In our analysis we have taken multiple viewpoints of 3GPP impact. It is clear that, no matter which viewpoint one takes, Ericsson is the leader in 3GPP and has influenced the technology in 5G over the years more than any other contributor.

Ericsson 5G leadership facts

Ericsson is the leader in 3GPP and the lead influencer in developing the technology in 5G.

Here are some further proof points of our 5G standardization leadership:

— Since 1999, Ericsson has made approximately 50,000 contributions to 3GPP to develop 2G, 3G, 4G and 5G – that's 15,000 more than any other company.
— As early as 2011, Ericsson already started to lead the industry discussions around 5G, scoping out 5G services and requirements, and researching and developing the 5G technical concept.
— Ericsson currently holds the most chairmanships and vice chairman positions in 3GPP. The chair is elected among 3GPP members.
— Ericsson's 5G technical contributions have been recognized with numerous 5G awards.
— Ericsson is so confident in its impact on, and contribution to, 5G standardization that in March 2017 we articulated our 5G licensing conditions for handsets ahead of the standard definition.
— To date, we have declared to ETSI that more than 1,400 Ericsson inventions could be essential for 5G. As release 15 of the 5G/NR standard was finalized in June 2018, we will soon begin to know the number of essential patents, and that number will increase on a rolling basis as the patents are issued.
— In November 2017, we made public our landmark 5G patent application, incorporating numerous Ericsson inventions into a complete architecture for the 5G network standard, which we filed as a pioneering 5G patent application already in Q2 2016. This was the largest patent application ever in cellular communications in terms of number of inventors (130) anywhere in the world.

Ericsson enables communications service providers to capture the full value of connectivity. The company's portfolio spans Networks, Digital Services, Managed Services, and Emerging Business and is designed to help our customers go digital, increase efficiency and find new revenue streams. Ericsson's investments in innovation have delivered the benefits of telephony and mobile broadband to billions of people around the world. The Ericsson stock is listed on Nasdaq Stockholm and on Nasdaq New York.

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