EDITOR: Joshua J. Yi, josh@joshuayipatentlaw.com

DEPARTMENT: MICRO LAW

Analysis of Historical Patenting Behavior and Patent Characteristics of Computer Architecture Companies—Part XI: Patent Families

Joshua J. Yi, *The Law Office of Joshua J. Yi, PLLC, Austin, TX, 78750, USA*

In previous parts of this series, I analyzed

- The numbers of issued patents and computer architecture patents.
- The prosecution time and effective patent term.
- The number of claims, breakdown of independent and dependent claims, and effect that excess claim fees had on the numbers of total and independent claims.
- The type of claims (apparatus, method, or Beauregard), and the effect that the U.S. Supreme Court's decision in *Alice v. CLS Bank* had on the number of independent and dependent method claims.
- The number of "backward" citations to U.S. patents and publications, foreign patents, and Other References, and the number of "forward" citations to a patent by another U.S. patent or U.S. patent publication.
- The correlation between prosecution time and number of claims, and the effect of the technology center on the correlation.
- The characteristics of patent families, including the percentage of patent families with only one issued patent, the average number of patents per family, and the correlation between the number of patents in a company's portfolio and the average number of patents in its multipatent families.
- The number of all patents and the number of computer architecture patents in the five largest patents' families for each company, and the percentage of all patents and computer architecture patents in the five largest patent families for patents issued to 18 leading computer architecture companies that were filed between 1996 and 2020.

This article continues analyzing the characteristics of patent families, which is particularly interesting because larger patent families are generally considered to be more valuable and may cover more significant inventions.

In this article, patents are in the same family if they have the same U.S. Patent and Trademark Office (USPTO) family identification (FMID) number. A patent has the same FMID if it is a continuation patent (a patent that claims priority to another patent) or continuation-in-part patent (a patent that claims priority to another patent, but includes some new material, i.e., not in the priority patent, that has a later priority date). The FMID does not appear to include divisional patents (a patent that claims priority to another patent, but covers a different invention, so it is "divided" out).

Table 1 lists the number of patents that were filed between 1 January 1996 and 31 December 2020 and that issued by 31 March 2022 for each of the 18 companies. The right-most column lists the number of patents that are classified as computer architecture patents,[a] while the middle column lists the number of all patents, i.e., computer architecture and noncomputer architecture ("All Patents"). During this time frame, some companies merged (e.g., Dell merged with EMC) or made significant acquisitions (e.g., Avago acquired Broadcom). To ensure that the results accurately reflect the present form of combined companies,

[a]I classified a patent as a "computer architecture" patent if it was classified in the 345, 708, 709, 710, 711, 712, 713, or 714 patent classes of the U.S. Patent Classification System or G06F, G06T, G09G, G11B, G11C, H03M, or H04L patent classes of the Cooperative Patent Classification System. These are the same patent classes that I used in parts 1–5 of this article series.

0272-1732 © 2024 IEEE
Digital Object Identifier 10.1109/MM.2024.3433209
Date of current version 14 August 2024.

I included the merged or acquired companies if 1) the companies were computer architecture companies and/or 2) had a significant number of patents.

To improve readability, I refer to companies with multiple entities generally by the parent company's name. More specifically, I refer to AMD+ATI as *AMD*, Dell+EMC+VMware as *Dell+EMC*, Marvell+Cavium as *Marvell*, NXP+Freescale as *NXP*, Renesas+Dialog+IDT+Intersil as *Renesas*, and Via+Cyrix as *Via*. In addition, I refer to Avago+Broadcom as *Broadcom* as the latter may be the more well-known company and the company that is more relevant with respect to computer architecture.

This article focuses on analyzing the average number of claims in multipatent families as compared to the average number of claims in single-patent families. A company may have a larger average number of claims in its multipatent families (as compared to its single-patent families) because that company believes that the patents in multipatent families are more valuable, and that it is worth the additional effort and cost to get more issued claims per each patent to protect those inventions more fully. On the other hand, a company with a smaller average number of claims in its multipatent families may believe that it is not worth the additional effort and cost to get more issued claims for any particular patent because it can apply for another patent with the claims that were not issued in the first patent. For example, if a company files an application with 30 claims and the PTO allows 18 of them, rather than arguing with the PTO that the other 12 claims should also be allowed, the company may elect to have the 18 allowed claims issue and file a continuation patent application with the 12 rejected claims (and some additional ones). The advantage of this approach is that the first patent will have an earlier issue date, which allows it to be enforced earlier and while the second patent will have additional claims to protect additional aspects of the invention (albeit with a later issue date). The consequence of this approach is that the average number of claims for patents in multipatent families will likely be lower as compared to the average number of total claims for companies that use the former approach.

TABLE 1. Number of all patents and computer architecture patents filed between 1 January 1996 and 31 December 2020 that issued by 31 March 2022.

Company	All Patents	Computer Architecture Patents
Amazon	16,383	9268
AMD	11,189	4631
Apple	27,968	12,308
ARM	2782	2372
Broadcom	14,757	6292
Dell+EMC	21,427	18,264
IBM	133,932	82,821
Intel	45,680	24,467
Marvell	8626	5185
Microsoft	47,562	31,999
MIPS	273	271
Nvidia	3957	3057
NXP	11,831	3729
Qualcomm	29,242	10,082
Renesas	14,384	4021
Samsung	136,054	33,301
SiFive	14	8
Via	1981	1320

DIFFERENCES IN AVERAGE NUMBER OF CLAIMS FOR SINGLE- AND MULTIPATENT FAMILIES

Table 2 shows the average number of total, independent, and dependent[b] claims for single- and multipatent families. The final three columns show the percentage difference in the average number of each type of claim in the multipatent families as compared to the single-patent families.

It is worth noting that a previous article in this series showed that the percentage of design patents for Apple, Microsoft, and Samsung was 12.7%, 8.3%, and 8.4%, respectively, of each company's patents.[1] Because design patents only have one claim and in practice have only one patent per family, a large percentage of design patents reduces the average number of total, independent, and dependent claims for *single*-patent families, which concomitantly artificially increases the percentage change in the average number of total, independent, and dependent claims for multipatent families, as compared to single-patent families. To eliminate this misleading result, the data in Table 2 for these three companies exclude design patents.

Note that SiFive does not appear in Table 2 because it does not have any multipatent families.

[b]Dependent claims are those that refer back to a previous claim, whereas independent claims do not refer to any claim.

TABLE 2. Average number of claims for single-patent families and multipatent families, and percentage difference for multipatent families (MPF) versus single-patent families (SPF). For Apple, Microsoft, and Samsung, the results for single-patent families exclude design patents.

	Single-Patent Families			Multipatent Families			Percentage Difference (MPF – SPF)		
Company	Total	Independent	Dependent	Total	Independent	Dependent	Total	Independent	Dependent
Amazon	20.2	3	17.2	22.1	3.2	18.9	9.3	3.9	10.2
AMD	19.8	3.1	16.7	16.3	2.6	13.7	−17.4	−16.9	−17.6
Apple	21.9	3.3	18.6	22.8	3.4	19.4	3.9	2.5	4.2
ARM	19.3	3.3	16	20.2	3.2	16.9	4.8	−0.3	5.8
Broadcom	21.3	3.1	18.2	21.1	3.1	18	−0.7	0.5	−0.9
Dell+EMC	18.9	3.1	15.8	18.9	3	15.8	−0.3	−3.1	0.3
IBM	18.3	3.2	15.1	13.8	2.3	11.5	−24.5	−28.3	−23.7
Intel	20.7	3.5	17.2	18.5	3	15.5	−10.7	−13.4	−10.2
Marvell	25.7	3.7	22	22	2.9	19.1	−14.2	−20	−13.3
Microsoft	20.6	3.3	17.3	19.6	3.2	16.4	−4.6	−1.3	−5.2
MIPS	26.3	4.5	21.9	23.6	3.7	20	−10.2	−17.7	−8.7
Nvidia	20.3	3.2	17.1	19.6	3.2	16.5	−3.3	−0.6	−3.8
NXP	17	2.7	14.3	15.6	2.4	13.1	−8.5	−11.2	−8
Qualcomm	29.5	4.9	24.6	29.9	4.9	25	1.1	0	1.3
Renesas	13.7	2.5	11.3	13.8	2.3	11.5	0.8	−5.8	2.3
Samsung	17.3	2.8	14.5	15.9	2.6	13.3	−8.3	−7.1	−8.5
Via	17	2.6	14.3	17.4	2.6	14.7	2.3	−0.5	2.9

The results in Table 2 show that the average number of total claims[c] for single-patent families ranges from 13.7 (Renesas) to 29.5 (Qualcomm) with a median of 20.2 while the average number of claims for multipatent families ranges from 13.8 (Renesas) to 29.9 (Qualcomm) with a median of 19.6. The percentage change in the average number of total claims for multipatent families and single-patent families ranges from −24.5% (IBM) to Amazon (9.3%), with a median of −0.3%.

The percentage difference in the average number of total claims is negative, i.e., the average number of total claims in a company's multipatent families is lower than the average number of total claims in its single-patent families, for 11 companies (in ascending order: IBM, AMD, Marvell, Intel, MIPS, NXP, Samsung, Microsoft, Nvidia, Broadcom, and Dell+EMC), while it is positive for the remaining six companies (Renesas, Qualcomm, Via, Apple, ARM, and Amazon). Based on these results, it appears that IBM, AMD, Marvell, Intel, MIPS, NXP, Samsung, Microsoft, Nvidia, Broadcom, and Dell+EMC may believe that it is not worth the additional effort and cost to get more issued claims for each patent in a multipatent family because it can apply for another patent with the claims that were not issued in the first patent and other additional claims.

On the other hand, Amazon—and to a lesser degree, Renesas, Qualcomm, Via, Apple, and ARM—apparently believes that it is worth the additional effort and cost to get more issued claims for patents in a multipatent family as their average number of total claims is higher for multipatent families than for single-patent families. Looking at the percentages for the independent and dependent claims for these companies shows that most of the increase in the number of total claims is due to an increase in the number of dependent claims. For example, given that the average number of independent claims in Amazon's multipatent families increased by 3.9% and the

[c]The number of total claims is the sum of the number of independent claims and the number of dependent claims.

average number of dependent claims in Amazon's multipatent families increased by 10.2% while the percentage for the average number of total claims increased by 9.3% shows that most of the increase in the average number of total claims is due to an increase in the average number of dependent claims. This result is not particularly surprising as dependent claims are typically the majority of a patent's claims. For example, the median average number of independent claims for all companies and all patent families is 3.1, while the median average number of dependent claims is 16.2.

For ARM, Renesas, and Via, the percentage change for independent claims is negative, i.e., the average number of independent claims for multipatent families is lower than the average number of independent claims for single-patent families. This result is very surprising as one might expect that if the average number of total claims is higher for multipatent families as compared to single-patent families, the average number of independent claims for multipatent families would also be higher. More specifically, despite that the fact that the average number of total claims for multipatent families is 4.8%, 0.8%, and 2.3% higher for ARM, Renesas, and Via, respectively, the average number of independent claims for multipatent families is 0.3%, 5.8%, and 0.5% *lower* for ARM, Renesas, and Via, respectively.

Similarly, although the average number of independent claims for multipatent families for Qualcomm is technically positive (0.01%), it is essentially zero. Therefore, for ARM, Renesas, Via, and Qualcomm, because the average number of independent claims for multipatent families is lower (or equal to, in Qualcomm's case) than the average number of independent claims for single-patent families, it may indicate that the independent claims for the multipatent families are very broad, meaning that fewer independent claims are needed as compared to single-patent families. But because a broad claim may also be more likely to be invalid, these companies may have added more dependent claims to provide some validity protection for the broad independent claims.

Amazon and Apple are the two other companies that have a higher average number of total claims for their multipatent families as compared to their single-patent families: 9.3% and 3.9% (excluding design patents) higher, respectively. Like ARM, Renesas, Via, and Qualcomm, most of the higher average number of total claims for Amazon and Apple is due to a higher average number of dependent claims. But unlike ARM, Renesas, and Via, the average number of independent claims for the Amazon and Apple's multipatent families is also higher than their average number of independent claims for their single-patent families.

Turning back to the companies that had a lower average number of total claims for their multipatent families as compared to average number of total claims for their single-patent families, i.e., IBM, AMD, Marvell, Intel, MIPS, NXP, Samsung, Microsoft, Nvidia, Broadcom, and Dell+EMC, these companies can be divided into two groups. In the first group, the percentage change, as an absolute value, for the average number of *total* claims is smaller than the percentage change for the average number of *independent* claims. For example, for IBM, the percentage change for the average number of total claims for multipatent families as compared to single-patent families is −24.5%, while the percentage change for the average number of independent claims for multipatent families is −28.3%. The companies in this group include IBM, Marvell, Intel, MIPS, NXP, and Dell+EMC. In the second group, the percentage change, as an absolute value, for the average number of total claims is *larger* than the percentage change for the average number of independent claims. The companies in this group include AMD, Samsung, Microsoft, Nvidia, and Broadcom.

ONE POTENTIAL REASON WHY THE AVERAGE NUMBER OF INDEPENDENT CLAIMS DECREASED MORE THAN THE DECREASE IN THE AVERAGE NUMBER OF TOTAL CLAIMS IS THE COST DUE TO EXCESS CLAIM FEES.

One potential reason why the average number of independent claims decreased more than the decrease in the average number of total claims is the cost due to excess claim fees. After 8 December 2004, the USPTO started to charge fees for patent applications that had more than 20 total claims and/or three independent claims. Currently, for larger companies, the cost for each additional independent claim in excess of three is $480, while the cost for each additional total claim in excess of 20 is $100.[2] For context, the current fee for a utility patent application is $320. Due to the excess independent claim fees, the companies in the first group may have reduced the number of independent claims in their multipatent families as compared to single-patent families at a faster rate than they reduced the number of total claims as the

excess independent claim fee is almost five-times higher than the excess dependent claim fee.

The results show that, for four of the six companies in the first group, the average number of independent claims for their multipatent families is both 1) lower than the average number of independent claims for their single-patent families and 2) below or just above three. More specifically, IBM had an average of 3.2 independent claims for its single-patent families, but 2.3 for its multipatent families; Marvell had an average of 3.7 and 2.9, respectively; Intel had 3.5 and 3.0, respectively; and Dell+EMC had 3.1 and 3.0, respectively. Therefore, for these companies, it appears that they may have reduced the average number of independent claims for their multipatent families completely (IBM and Marvell), or almost completely (Intel and Dell+EMC), to avoid excess independent claim fees.

The two remaining companies in the first group, MIPS and NXP, exhibited different behavior. MIPS had an average of 4.5 independent claims for its single-patent families, but 3.7 for its multipatent families. So, although MIPS did not reduce the number of independent claims in its multipatent families to completely avoid the excess independent claim fee, it did significantly reduce their excess independent claim fees in their multipatent families by more than 50%. NXP, on the other hand, had an average of 2.7 independent claims for its single-patent families, but 2.4 for its multipatent families. As such, NXP did not have incur many excess independent claim fees for both its single- and multipatent families. More specifically, NXP incurred excess independent claim fees for 13.5% of its single-patent families, but only 10.2% of the patents in its multipatent families. But, although NXP incurred excess independent claim fees for a relatively small percentage of its single-patent families, it incurred an even smaller percentage for its multipatent families.

For the companies in the second group (Samsung, Microsoft, Nvidia, and Broadcom), the percentage difference, as an absolute value, in the average number of independent claims for multipatent families as compared to the average number of independent claims for single-patent families for these companies is smaller than the corresponding percentage difference for the companies in the first group. More specifically, the median percentage for companies in the second group is 1%, while the median percentage for companies in the first group is 16.9%. Given that the companies in both groups have a similar median average number of independent claims for single-patent families, namely, 3.19 for companies in the first group and 3.14 for companies in the second group, the fact that the companies in the second group have a smaller percentage decrease in the average number of independent claims for multipatent families could indicate that these companies are less motivated to reduce the excess independent claim fees.

Finally, of all the companies where the average number of total claims for multipatent families is smaller than the average number of total claims for single-patent families, Broadcom is the only company where the average number of independent claims is larger. More specifically, the average number of independent claims for multipatent families for Broadcom is 0.5% higher than the average number of independent claims for single-patent families, even though the average number of total claims is 0.7% lower.

The reason for this result appears to be that Broadcom's multipatent families have a slightly higher average number of independent claims (3.11) as compared to single-patent families (3.09) due to a few patents with a very large number of independent claims. More specifically, Broadcom's multipatent families have patents with 21, 23, 26, 27, 30, and 45 independent claims. By contrast, Broadcom's single-patent families have patents with 21, 29, and 36 independent claims. Omitting these patents for both multi- and single-patent families lowers the percentage difference in the average number of independent claims to −0.045%. Therefore, the reason that the average number of independent claims for multipatent families for Broadcom is higher than the average number of independent claims for single-patent families, even though the average number of total claims is lower, is due to a few patents from multipatent families with a very large number of independent claims.

The next article in this series will continue to examine the characteristics of the patent families for patents issued to these computer architecture companies.

REFERENCES

1. J. J. Yi, "Analysis of historical patenting behavior and patent characteristics of computer architecture companies—Part III: Claims," *IEEE Micro*, vol. 42, no. 4, pp. 124–132, Jul./Aug. 2022, doi: 10.1109/MM.2022.3180134.
2. "USPTO fee schedule." United States Patent and Trademark Office. Accessed: May 30, 2022. [Online]. Available: https://www.uspto.gov/sites/default/files/documents/USPTO-fee-schedule_current.pdf

JOSHUA J. YI is a solo practitioner at The Law Office of Joshua J. Yi, PLLC, Austin, TX, 78750, USA. Contact him at josh@joshuayipatentlaw.com.