DEPARTMENT: MICRO LAW

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

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n prior parts of this series, I analyzed the following:

› 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 Supreme Court's decision in *Alice v. CLS Bank* had on the numbers of independent and dependent method claims.
› The number of "backward" citations to U.S. patents and publications, foreign patents, and Other References as well as 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 as well as the effect of the technology center on this correlation.

This article analyzes the characteristics of patent families for patents issued to 18 leading computer architecture companies that were filed between 1996 and 2020. In this article, patents are in the same family if they have the same U.S. Patent and Trademark 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 were 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 timeframe, 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, 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 generally refer to companies with multiple entities 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.

Table 2 shows the number of patent families for all patents and for computer architecture patents.

Table 3 shows the average number of patents in each patent family for all patents and for computer architecture patents. The results in Table 3 are the

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[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 the 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 I–V of this article series.

TABLE 1. Number of all patents and computer architecture patents filed between 1 January 1996 and 31 December 2020 that were 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 + Cyrix	1981	1320

TABLE 2. Number of patent families for all patents and for computer architecture patents filed between 1 January 1996 and 31 December 2020 that were issued by 31 March 2022.

Company	All Patents	Computer Architecture Patents
Amazon	12,481	7040
AMD	10,141	4215
Apple	19,853	8232
ARM	2509	2159
Broadcom	11,214	4929
Dell + EMC	18,311	15,589
IBM	96,954	61,846
Intel	35,173	19,327
Marvell	5537	3401
Microsoft	37,341	24,846
MIPS	230	227
NVIDIA	3307	2555
NXP	11,034	3612
Qualcomm	24,823	8915
Renesas	11,203	3277
Samsung	118,235	29,089
SiFive	14	8
Via + Cyrix	1809	1183

result of dividing each column in Table 1 by the corresponding column in Table 2.

The results in Table 3 show that the average number of patents in each patent family ranges from 1.00 (SiFive) to 1.56 (Marvell), with a median of 1.19, for all patents and from 1.00 (SiFive) to 1.52 (Marvell), with a median of 1.20, for computer architecture patents. The reason that the average number of patents for SiFive patent families is 1.00 is because SiFive is a very young company, so any continuation and continuation-in-part patent applications it may have filed probably have not had enough time to issue.

Comparing the middle and right columns shows that the average number of patents in each patent family for all patents and the average number of patents in each patent family for computer architecture patents is very similar. The differences between the middle and right columns range between –0.09 and 0.06, which is only a difference of –6.1% and 4.4%, respectively. For six companies (Amazon, Apple, Dell + EMC, Microsoft, MIPS, and Via), the average number is

higher for computer architecture patents, while the average is higher for all patents of patents in each patent family for 10 companies (AMD, ARM, Broadcom, IBM, Intel, Marvell, NXP, Qualcomm, Renesas, and Samsung). For the remaining two companies, NVIDIA and SiFive, there is no difference in the average number of patents for all patents and for computer architecture patents. Based on these results, there does not appear to be a meaningful difference in the average number of patents in each patent family for all patents and for computer architecture patents.

Table 4 shows the percentage of patent families with only one patent in the family for each company. Having a higher percentage may indicate that the company has a wide breadth of inventions, as the company might choose to pursue patent protection for a wide range of inventions rather than choosing to pursue more comprehensive patent protection for a more limited number of inventions, i.e., through larger patent families. On the other hand, having a

TABLE 3. Average number of patents in each patent family for all patents and for computer architecture patents filed between 1 January 1996 and 31 December 2020 that were issued by 31 March 2022.

Company	All Patents	Computer Architecture Patents
Amazon	1.31	1.32
AMD	1.10	1.10
Apple	1.41	1.50
ARM	1.11	1.10
Broadcom	1.32	1.28
Dell + EMC	1.17	1.17
IBM	1.38	1.34
Intel	1.30	1.27
Marvell	1.56	1.52
Microsoft	1.27	1.29
MIPS	1.19	1.19
NVIDIA	1.20	1.20
NXP	1.07	1.03
Qualcomm	1.18	1.13
Renesas	1.28	1.23
Samsung	1.15	1.14
SiFive	1.00	1.00
Via + Cyrix	1.10	1.12

TABLE 4. Percentage of patent families with only one patent in the family.

Company	All Patents (%)	Computer Architecture Patents (%)
Amazon	78.4	74.6
AMD	90.7	93.0
Apple	76.4	65.6
ARM	93.6	93.8
Broadcom	79.6	76.5
Dell + EMC	89.4	89.3
IBM	71.9	72.9
Intel	80.4	81.3
Marvell	63.5	61.3
Microsoft	81.1	77.5
MIPS	86.5	86.8
NVIDIA	86.6	85.6
NXP	92.2	94.7
Qualcomm	86.6	84.3
Renesas	81.6	83.2
Samsung	89.7	87.4
SiFive	100.0	100.0
Via + Cyrix	94.1	93.7

lower percentage may indicate that the company has produced many significant inventions that require multiple patents for each invention to more fully protect those inventions.

The results in Table 4 show that the percentages of patent families with only one patent in the family ranges from 63.5% (Marvell) to 100.0% (SiFive), with a median percentage of 86.6%, for all patents, and from 61.3% (Marvell) to 100.0% (SiFive), with a median percentage of 85.0%, for computer architecture patents. For the same reason as was described, the reason the percentage for SiFive is 100% is because SiFive is a very young company, so any additional patents in a patent family probably have not had enough time to issue. Given that Marvell had the highest average number of patents in each patent family (1.56 for all patents and 1.52 for computer architecture patents), it is not surprising that Marvell has the lowest percentage of patent families with only a single patent.

The company with the largest difference in the percentage of patent families with only one patent in the family is Apple (76.4% for all patents and 65.6% for computer architecture patents); the next largest difference is 3.8% (Amazon). One potential reason for the large difference for Apple is the relatively large percentage of its patents that are design patents. Design patents protect how an article looks, or its "ornamental appearance," and are limited to one claim. As such, for at least those reasons, design patents generally do not have continuation or continuation-in-part patents. As such, a larger percentage of design patents would tend to increase the percentage of patent families with only one patent in the family.

Since design patents are not computer architecture patents and since Apple has the highest percentage of patents that are design patents,[1] it is unsurprising to see that the percentage of patent families with only one patent in the family is significantly higher for all patents as compared to the corresponding percentage for computer architecture patents. Based on that, it is unsurprising that the difference between the two for Apple is significantly higher than the difference for all other companies.

TABLE 5. The percentage of patents in families with two or more patents for each company.

Company	All Patents (%)	Computer Architecture Patents (%)
Amazon	40.3	43.3
AMD	17.8	15.3
Apple	45.7	56.1
ARM	15.6	14.6
Broadcom	39.5	40.0
Dell + EMC	23.6	23.8
IBM	48.0	45.5
Intel	38.1	35.8
Marvell	59.2	59.8
Microsoft	36.4	39.8
MIPS	27.1	27.3
NVIDIA	27.6	28.4
NXP	14.0	8.2
Qualcomm	26.5	25.5
Renesas	36.4	32.2
Samsung	22.1	23.6
SiFive	0.0	0.0
Via + Cyrix	14.1	16.1

The results in Table 4 show that there is a difference in the percentage of patent families with only one patent in the family for 1) companies with more patents as compared to 2) companies with fewer patents. Companies in the former group include Samsung (136,054 issued patents), IBM (133,932), Microsoft (47,562), Intel (45,680), Qualcomm (29,242), Apple (27,968), and Dell + EMC (21,427). Companies in the latter group include Amazon (16,383), Broadcom (14,757), Renesas (14,384), NXP (11,831), AMD (11,189), Marvell (8626), NVIDIA (3957), ARM (2782), Via (1981), MIPS (273), and SiFive (14).

For the former group of companies, the percentage of patent families with only one patent ranges from 71.9% (IBM) to 89.7% (Samsung), with a median of 81.1%, for all patents and from 65.6% (Apple) to 89.3% (Dell + EMC), with a median of 81.3%, for computer architecture patents. For the latter group of companies but excluding Marvell and SiFive, the percentage of patent families with only one patent ranges from 78.4% (Amazon) to 94.1% (Via), with a median of 86.6%, for all patents and from 74.6% (Amazon) to 94.7% (NXP), with a median of 86.8%, for computer architecture patents. In other words, for all patents and for computer architecture patents, the latter group of companies has higher percentage of single-patent families as compared to the former group of companies. This may indicate that these companies opt for a wider breadth—but shallower depth—of patent protection or that finances prohibit these companies from pursuing additional continuation and continuation-in-part patents.

> ONE POTENTIAL REASON FOR THE LARGE DIFFERENCE FOR APPLE IS THE RELATIVELY LARGE PERCENTAGEOF ITS PATENTS THAT ARE DESIGN PATENTS.

On the other hand, the lower percentage of single-patent families for the companies with more patents may indicate that these companies prefer more depth than additional breadth in their patent portfolio or that these companies come up with significant inventions that require more continuation and continuation-in-part patents to cover all aspects of the inventions.

Table 5 shows the percentage of patents that are in families with two or more patents for each company.

After excluding SiFive because it does not have any multipatent families, Table 5 shows that patent families that have two or more patents account for 14.0% (NXP) to 59.2% (Marvell) of each company's issued patents, with a median of 27.6%, for all patents and for 8.2% (NXP) to 59.8% (Marvell), with a median of 28.4%, for computer architecture patents. While the results in Table 4 show that, for all companies, more than 80% of patent families are single-patent families, the results in Table 5 show that patent families with two or more patents account for a significant percentage of the total number of patents.

The results in Table 5 also show that, for companies with more issued patents (Samsung, IBM, Microsoft, Intel, Qualcomm, Apple, and Dell + EMC), patent families that have two or more patents account for 22.1% (Samsung) to 48.0% (IBM) of each company's issued

patents, with a median of 36.4%, for all patents and for 23.6% (Samsung) to 56.1% (Apple), with a median of 35.8%, for computer architecture patents. For the latter group of companies, i.e., those with fewer issued patents, again excluding SiFive, the percentage of patent families with two or more patents ranges from 14.0% (NXP) to 59.2% (Marvell), with a median of 27.4%, for all patents and from 8.2% (NXP) to 59.8% (Marvell), with a median of 27.9%, for computer architecture patents. These results are unsurprising, given that the companies with fewer issued patents have a higher percentage of single-patent families, which means it is more likely that they would also have a smaller percentage of patents in patent families with two or more patents. The reverse is also true; namely, companies with more issued patents have a lower percentage of single-patent families, which means it is more likely that they would also have a larger percentage of patents in patent families with two or more patents.

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

REFERENCE

1. J. J. Yi, "Analysis of historical patenting behavior and patent characteristics of computer architecture companies—Part V: References," *IEEE Micro*, vol. 42, no. 6, pp. 135–140, Nov./Dec. 2022, doi: 10.1109/MM.2022.3209765.

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