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DEPARTMENT: MICRO LAW

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

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In 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 number 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 the correlation.
- The characteristics of patent families, including the percentage of patent families with only one issued patent and the average number of patents per family 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. 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 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 the companies 1) 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

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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 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

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, for all issued patents and for computer-architecture-only patents, the percentage of families that are multipatent families (columns 2 and 3) and the average number of patents in multipatent families (columns 4 and 5). Because SiFive does not have any multipatent families (likely because it is a new company, so it has not had enough time to pursue multipatent families), it is not in included in Table 2.

The results in Table 2 show that the percentage of patent families that are multipatent families ranges from 5.9% (Via) to 36.5% (Marvell), with a median of 13.5% for all patents, while the percentages for computer architecture patents range from 5.3% (NXP) to 38.7% (Marvell), with a median of 15.7%. A lower percentage may indicate that the company has a wide breadth of inventions, as the company might choose to pursue patent protection for a wider 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 higher 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 2 also show that the average number of patents in multipatent families ranges from 2.11 (AMD) to 2.74 (Apple), with a median of 2.47 for all patents, while the average for computer architecture patents ranges from 2.15 (Samsung) to 2.83 (Via), with a median of 2.37.

To examine the relationship between the number of patents and the percentage of patent families that are multipatent families or the average number of patents in multipatent families, Table 3 shows that correlation for all issued patents and for computer architecture patents only. More specifically, column 2 shows the correlation between the number of all issued patents and the percentage of patent families that are multipatent families for different groups of companies (in rows 2 to 4). Column 3 shows the same thing but for computer architecture patents only. Column 4 shows the correlation between the number of all issued patents and the average number of patents in multipatent families, while column 5 shows the same thing for computer architecture patents only.

The second row in Table 3 presents the correlations across all companies, while the third and fourth rows present the correlations for companies with a lot of patents ("High Patent") and companies with fewer patents ("Low Patent"), respectively. 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).

With respect to the correlation between the number of patents and percentage of patent families that are multipatent families, the results in columns 2 and 3 show that there is a small to medium positive correlation, which indicates that, as a company has more issued patents within the high-patent and low-patent groups, the percentage of multipatent families increases. This result could be because companies believe that it is more efficient to increase their number of patents by pursuing patent applications from already existing patent families. This may also be because inventions in a patent family represent more significant inventions and, thus, require more patents to fully protect. In addition, it may be faster and/or less costly to pursue patent

TABLE 2. Percentage of patent families that are multipatent families and the average number of patents in multipatent families for all issued patents and for computer-architecture-only patents.

Company	Families That Have Two or More Patents, %		Average Number in Patent Families With Two or More Patents	
	All Patents	Computer Architecture Patents	All Patents	Computer Architecture Patents
Amazon	21.6	25.4	2.45	2.25
AMD	9.3	7.0	2.11	2.41
Apple	23.6	34.4	2.74	2.44
ARM	6.4	6.2	2.70	2.59
Broadcom	20.4	23.5	2.55	2.18
Dell + EMC	10.6	10.7	2.61	2.60
IBM	28.1	27.1	2.36	2.25
Intel	19.6	18.7	2.53	2.42
Marvell	36.5	38.7	2.53	2.35
Microsoft	18.9	22.5	2.44	2.28
MIPS	13.5	13.2	2.39	2.47
NVIDIA	13.4	14.4	2.47	2.37
NXP	6.5	5.3	2.19	2.25
Qualcomm	13.4	15.7	2.33	2.41
Renesas	18.4	16.8	2.55	2.35
Samsung	10.3	12.6	2.46	2.15
Via + Cyrix	5.9	6.3	2.61	2.83

applications from the same family as compared to pursuing a patent application from a completely new patent family.

Comparing the results in rows 3 and 4 shows that the correlation for companies with fewer issued patents (0.26 and 0.46) is significantly higher than the correlation for companies with a larger number of patents (0.06 and 0.11). This result may indicate that companies with fewer patents (in row 4) tend to increase the number of multipatent families by pursuing patent applications in single-patent families as compared to companies with more patents (in row 3). By contrast, there is almost no correlation between the number of patents and percentage of patent families that are multipatent families for companies with a larger number of patents (row 3). This result may indicate these companies may have different patenting strategies, so there is no correlation between the number of patents and the percentage of patent families that are multipatent families.

With respect to the correlation between the number of patents and the average number of patents in multipatent families, the results in columns 4 and 5 show that there is a small to significant *negative* correlation. In other words, as companies increase their number of patents, the average number of patents in multipatent families decreases.

THERE IS ALMOST NO CORRELATION BETWEEN THE NUMBER OF PATENTS AND PERCENTAGE OF PATENT FAMILIES THAT ARE MULTIPATENT FAMILIES FOR COMPANIES WITH A LARGER NUMBER OF PATENTS.

Putting the results in columns 2 and 3 together with the results in columns 4 and 5 shows that, as the number of patents increases, the number of patent families increases somewhat, but the average number of patents per multipatent family decreases (and, potentially, at a faster rate due to the stronger correlation), which could indicate that the number of patents

TABLE 3. Correlation between the number of patents and percentage of patent families that are multipatent families or the average number of patents in multipatent families.

Company	Families That Have Two or More Patents, %		Average Number in Patent Families With Two or More Patents	
	All Patents	Computer Architecture Patents	All Patents	Computer Architecture Patents
All companies	0.21	0.29	–0.12	–0.35
High patent	0.06	0.11	–0.42	–0.24
Low patent	0.26	0.46	–0.44	–0.61

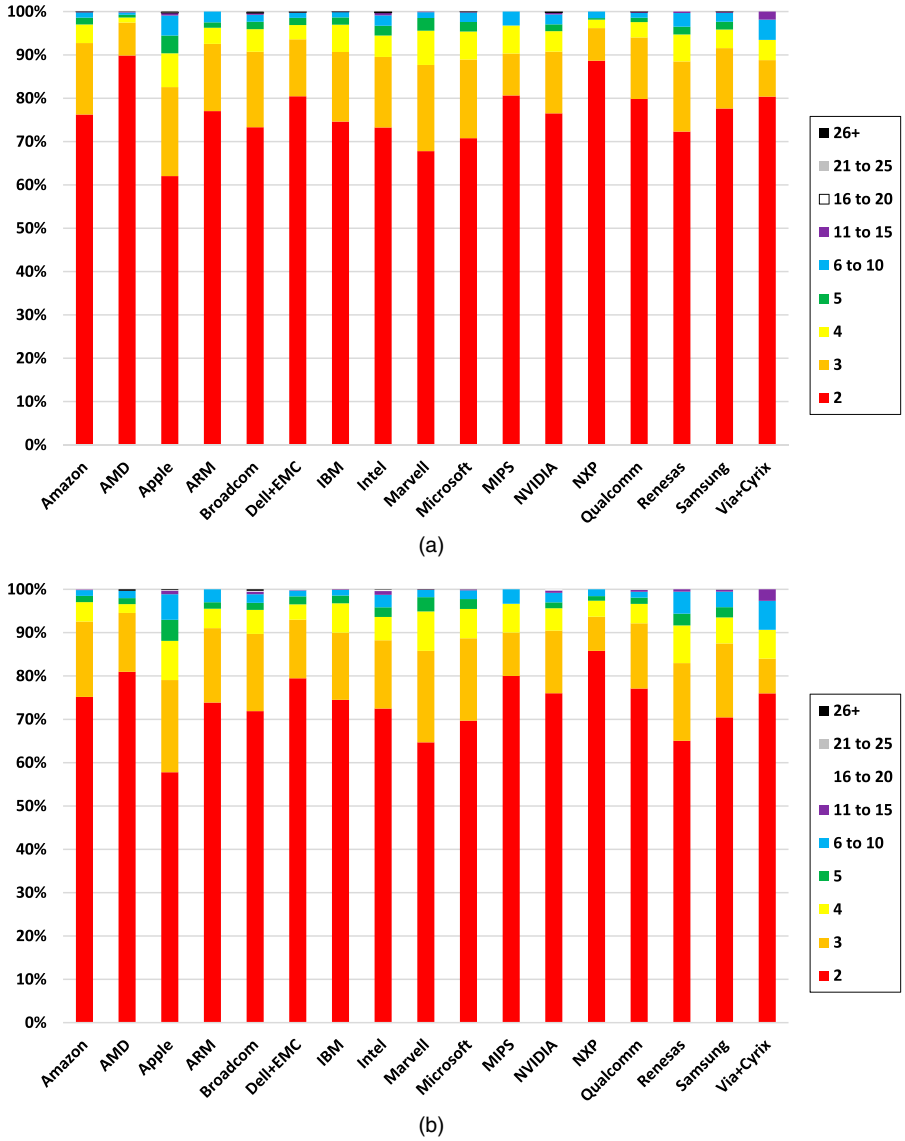

FIGURE 1. Histogram of counts of each size patent family, for multipatent families. (a) All patents. (b) Computer architecture patents.

in larger families is not increasing as much as the number of patent families. This result could be explained by the fact that after 8 June 1995, the United States changed the length of patent terms from 17 years from the filing of each patent to 20 years from the filing of the earliest patent. Therefore, a patent application claiming priority to the oldest member of its patent family has a shorter effective patent term length than if it did not claim priority (but the earlier priority date allows it to have priority over any potential prior art references that became publicly available between the earlier priority date and the filing of the latest patent application). Furthermore, as the number of patents in a family increases, the effective patent term for each new member of the family also likely decreases.

IN OTHER WORDS, AS COMPANIES INCREASE THEIR NUMBER OF PATENTS, THE AVERAGE NUMBER OF PATENTS IN MULTIPATENT FAMILIES DECREASES.

For example, assume the first patent in a multipatent family was filed on January 1996 and that the next four patents were filed on 1 January 1998, 1 January 2000, 1 January 2002, and 1 January 2004. The priority date for all five patents is 1 January 1996, and, thus, the expiration of all five patents is all on 31 December 2016, i.e., 20 years after the filing of the earliest patent (absent any patent term extensions). As such, the effective patent terms of the patents are 20, 18, 16, 14, and 12 years, respectively. Because the alternative is to pursue patents that have a longer patent term, the increasingly shorter patent term is a diminishing return that could ultimately decrease the number of patents in larger patent families (as compared to if every patent in the family had a 20-year patent term), which concomitantly could decrease the average number of patents in a patent family.

Figure 1 depicts a histogram of the counts of each size of patent family for multipatent families as a percentage of the total number of multipatent families. For example, the red bar for Amazon shows that 76.3% of Amazon's multipatent families have two patents in them. The orange bar for Amazon shows that 16.5% have three patents in them. Because SiFive only has single-patent families, Figure 1 does not depict the SiFive.

The results in Figure 1 show that, for all companies, the vast majority of multipatent families have only two patents in them. More specifically, for all issued patents, two patent families account for 62.0% (Apple) to 89.8% (AMD), with a median of 76.5%, while, for computer architecture patents, two patent families account for 57.8% (Apple) to 85.8% (Renesas), with a median of 74.5%. Comparing the percentages for all issued patents and computer architecture patents shows that computer architecture patents generally have a lower percentage of patents for a given patent family size (and smaller), which indicates that computer architecture patents may have larger patent families as compared to all issued patents for each company. The fact that computer architecture patents might have larger patent families could indicate that the computer-architecture-related inventions are more significant and, thus, require more patents to fully cover the invention.

The results in Figure 1 also show that relatively small patent families account for almost all multipatent families. More specifically, patent families with two to five patents account for 93.5% (Via) to 99.3% (Microsoft), with a median of 97.6% for all issued patents, and 90.7% (Via) to 98.6% (Broadcom), with a median of 97.0% for computer architecture patents.

TABLE 4. Number of patents in the largest patent family for each company.

Company	Number of Patents
Amazon	18
AMD	32
Apple	41
ARM	8
Broadcom	34
Dell + EMC	25
IBM	41
Intel	45
Marvell	26
Microsoft	42
MIPS	7
NVIDIA	20
NXP	9
Qualcomm	22
Renesas	14
Samsung	29
SiFive	1
Via + Cyrix	14

On the other hand, several companies have very large patent families. More specifically, AMD, Apple, Broadcom, IBM, Intel, Marvell, Microsoft, and Samsung all have patent families with 26 or more patents, while Dell + EMC and Qualcomm both have patent families with 21 to 25 patents.

Table 4 shows that number of patents in the largest patent family for each company.

The results in Table 4 show that the companies with fewer issued patents (AMD, ARM, Marvell, MIPS, NVIDIA, NXP, Renesas, SiFive, and Via + Cyrix) generally have smaller patent families. More specifically, the largest patent family for ARM, MIPS, NXP, and SiFive has fewer than 10 patents in each. However, this trend is not universal for all companies with fewer issued patents. For example, the largest patent family for AMD has 32 patents, which is the fifth largest patent family for these companies. Additionally, even though Via has the third fewest number of patents, its largest patent family has 14 patents in it, which is more patents than the largest patent families for companies that have more issued patents (ARM, NXP, and Renesas).

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

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