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DEPARTMENT: MICRO LAW

Analysis of Historical Patenting Behavior and Patent Characteristics of Computer Architecture Companies—Part X: 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, 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 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 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,[1] while the middle column lists the number of all patents, i.e., computer architecture and non-computer architecture ("All Patents"). During this timeframe, some companies merged (e.g., Dell merged with EMC) or made significant acquisitions (e.g., Avago acquired Broadcom). In order 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 will refer to companies with multiple entities generally by the parent company's name. More specifically, I will 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 will refer to Avago+Broadcom as

0272-1732 © 2024 IEEE
Digital Object Identifier 10.1109/MM.2024.3394670
Date of current version 6 June 2024.

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	3,729
Qualcomm	29,242	10,082
Renesas	14,384	4021
Samsung	136,054	33,301
SiFive	14	8
Via	1981	1320

"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 all patents in the five largest patent families (Column 2) and the number of those patents that are classified as computer architecture patents (Column 3). Column 4 shows what percentage of all patents the five largest patent families account for, while Column 5 shows the corresponding percentage for computer architecture patents. It is important to note that Table 2 only shows the patent families that are "homegrown" and not transferred. "Homegrown" patents are those that a company invented, such that the first (i.e., oldest) patent in each family was invented by that company. Table 2 excludes patents that a company may have invented, but transferred, e.g., sold, to another company. Including transferred patents in Table 2 presents an "accounting" problem. For example, Intel sold a patent family to Apple with 40 issued patents. Apple then continued to apply for patents in that family, ultimately ending up with another four patents. Therefore, for the purposes of Table 2, which company—Intel or Apple—should that patent family be assigned to? And should a patent family only include the patents that the company applied for or all patents in the family? Because there are good arguments to include a patent family as part of the transferor company or as part of the transferee company, and because those arguments depend on the exact facts, Table 2 excludes transferred patent families. A future article will separately analyze transferred patent families.

It is important to note that a patent family may comprise both computer architecture patents and noncomputer architecture patents, i.e., a patent family is not necessarily 100% computer architecture patents or 100% noncomputer architecture patents.

Finally, SiFive does not appear in Table 2 (or Table 3) because it does not have any patent families with two or more patents.

The results in Table 2 show that the number of patents in the five largest patent families ranges from 21 (MIPS) to 155 (Broadcom), with a median of 69 for all patents (Column 2) and 0 (NXP) to 98 (Intel), with a median of 45 for computer architecture patents (Column 3). Six companies—Broadcom, IBM, Intel, Apple, Microsoft, and Samsung—have over 100 patents in their five largest patent families, which averages out to over 20 patents in each patent family. With the exception of Broadcom, the other five companies are companies with the largest number of patents, and likely the companies with the highest revenue. As such, it is not surprising that IBM, Intel, Apple, Microsoft, and Samsung have very large patent families as they have the money to continue to apply for patents in the same family and/or they invent very large inventions that require multiple patents to protect.

By contrast, Broadcom has the ninth-most number of all patents (out of 17 companies), but its five largest patent families average over 30 patents per family. The average number of patents in Broadcom's multipatent families is 2.55, which is only slightly above the median of 2.47.[a] Given that Broadcom 1) does not have a very large number of patents and 2) does not have a very high average number of patents per multipatent family, but has the largest number of patents in its five largest families, this may indicate that when Broadcom

[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 I–V of this article series.

TABLE 2. Number of patents in the five largest patent families (Columns 2 and 3) and percentage of patents in the five largest patent families (Columns 4 and 5), for all patents and computer architecture patents.

Company	Number of Patents		Percentage of Patents	
	All Patents	Computer Architecture Patents	All Patents	Computer Architecture Patents
Amazon	69	36	0.42%	0.39%
AMD	58	51	0.52%	1.10%
Apple	111	32	0.40%	0.26%
ARM	31	26	1.11%	1.10%
Broadcom	155	71	1.07%	1.13%
Dell+EMC	78	71	0.36%	0.39%
IBM	140	45	0.10%	0.05%
Intel	128	98	0.28%	0.40%
Marvell	67	46	0.78%	0.89%
Microsoft	107	41	0.22%	0.13%
MIPS	21	21	7.69%	7.75%
NVIDIA	60	52	1.52%	1.70%
NXP	33	0	0.28%	0.00%
Qualcomm	82	53	0.28%	0.53%
Renesas	66	28	0.46%	0.70%
Samsung	103	20	0.08%	0.06%
Via	48	48	2.42%	3.64%

believes that when it has an important and/or valuable invention that requires multiple patents to fully protect, Broadcom will uncharacteristically, as compared to their typical practice, aggressively apply for patents to protect those inventions.

On the other hand, none of the patents in NXP's five largest patent families are classified as a computer architecture patent. This result may be explained by the fact that NXP has a relatively small number of patents in its five largest patent families (33) and NXP has the second lowest percentage of its patents that are computer architecture patents (28.0%). Based on that, it is not very surprising that none of the patents in NXP's five largest patent families are a computer architecture patent.

The results in Table 2 further show that the percentage of all patents and computer architecture patents, respectively, that are in the five largest patent families ranges from 0.08% (Samsung) to 7.69% (MIPS), with a median of 0.42% for all patents (Column 4) and 0.00% (NXP) to 7.75% (MIPS), with a median of 0.53% for the computer architecture patents (Column 5). The results in Columns 4 and 5 show that companies with fewer patents ("Low Patent") generally have a higher percentage than the companies with more patents ("High Patent"). Patents in the former group include Amazon (16,383 issued patents), Broadcom (14,757), Renesas (14,384), NXP (11,831), AMD (11,189), Marvell (8626), NVIDIA (3957), ARM (2782), Via (1981), and MIPS (273) while companies in the latter group include Samsung (136,054), IBM (133,932), Microsoft (47,562), Intel (45,680), Qualcomm (29,242), Apple (27,968), and Dell+EMC (21,427). More specifically, the nine companies with the highest percentages, MIPS (7.69%), Via (2.42%), NVIDIA (1.52%), ARM (1.11%), Broadcom (1.05%), Marvell (0.78%), AMD (0.52%), Renesas (0.46%), and Amazon (0.42%) are all companies in the Low Patent Group. The only company in the Low Patent group that does not have a relatively high percentage is NXP, which has a percentage of 0.28%, which is the 14th highest number of patents (out of 17 companies) in Table 2. In other words, companies with a smaller number of total patents generally have a much larger percentage of patents in their five largest patent families. This is likely because these companies tend to be selective about which inventions to seek patent

TABLE 3. Percentage of computer architecture patents for all issued patents and for the five largest patent families; difference = Top 5 - All.

Company	Issued Patents	Top 5 Patent Families	Difference
Amazon	56.6%	52.2%	-4.4%
AMD	41.4%	87.9%	46.5%
Apple	44.0%	28.8%	-15.2%
ARM	85.3%	83.9%	-1.4%
Broadcom	42.6%	45.8%	3.2%
Dell+EMC	85.2%	91.0%	5.8%
IBM	61.8%	32.1%	-29.7%
Intel	53.6%	76.6%	23.0%
Marvell	60.1%	68.7%	8.5%
Microsoft	67.3%	38.3%	-29.0%
MIPS	99.3%	100.0%	0.7%
NVIDIA	77.3%	86.7%	9.4%
NXP	31.5%	0.0%	-31.5%
Qualcomm	34.5%	64.6%	30.2%
Renesas	28.0%	42.4%	14.5%
Samsung	24.5%	19.4%	-5.1%
Via	66.6%	100.0%	33.4%

protection for, so they pursue a smaller number of patent applications (i.e., the denominator in Columns 4 and 5 tends to be smaller for Low Patent companies). But when they believe they have a significant invention, they appear to apply for more patents than they would otherwise typically do (i.e., the numerator in Columns 4 and 5 tends to be larger than it otherwise would). With the exception of Broadcom, given that the size of the five largest patent families for the Low Patent companies (21 to 69 patents) are all smaller than the corresponding number for the smallest High Patent company (Dell+EMC with 78 patents), this tends to indicate that the higher percentages in Columns 4 and 5 for the Low Patent companies is primarily due to those companies getting a smaller number of patents (i.e., the denominator) than having usually large patent families (i.e., the numerator).

The reason NXP has such a low percentage is because its five largest patent families are comparatively small. More specifically, NXP has the third fewest number of patents in its five largest patent families (33), which is slightly more than ARM (31) and MIPS (21). But the total number of all patents for ARM and MIPS is 2782 and 273, respectively, which are significantly smaller than NXP's 11,831 total patents. In other words, NXP has a similar number of all patents as ARM and MIPS in its five largest patent families despite having 4.3 times and 43.3 times, respectively, more total patents. On the other hand, Via has 48 patents in its five largest patent families while having only 1981 total patents. In other words, Via has 45.5% more patents than NXP in its five largest patent families despite having 16.7% as many total patents as NXP.

The two companies that are closest to NXP in terms of the total number of all patents are Renesas (14,384) and AMD (11,189). They have 66 and 58, respectively, patents in their five largest patent families, both of which are approximately double the corresponding number for NXP. If NXP had a similar percentage of patents in its five largest patent families as Renesas and AMD do (0.46% to 0.52%), NXP would have had 54.4 to 61.5 patents in its five largest patents families, instead of having just 33 patents.

There are at least three reasons that could account for why NXP's five largest patent families are unusually small. First, NXP may believe that because the scope of the patents in these families is already very broad, getting additional patents may not meaningfully increase the overall scope of each patent family. Second, NXP may believe that, due to the fact that the effective

term for additional patents in a patent family is shorter, getting more patents in a family beyond a certain number might yield insufficient benefit for the cost and effort. Third, a significant part of NXP's patent portfolio originated from Freescale, which was owned by private equity investors from 2006 to 2015. That timeframe is a significant fraction of the relevant timeframe for this article (1996 to 2020). Due to the debt that the private equity owners assumed when buying Freescale, Freescale may have reduced its patent applications in favor of servicing its debt, which may somewhat reduce the size of the five largest patent families for the combined NXP+Freescale company.

Finally, the percentages in Column 5, which are for the computer architecture patents, are similar to those in Column 4, namely, the highest percentages are for companies in the Low Patent group.

Table 3 shows the percentage of a company's patents that are computer architecture patents for all its patents (Column 2) and for the five largest patent families only (Column 3). Comparing Columns 2 and 3 could indicate whether each company's most valuable patents (i.e., those in the five largest patent families) are more or less likely—as compared to the company's entire patent portfolio—to be computer architecture patents. Column 4 presents the difference between the percentage for the Column 3 ("Top 5 Patent Families") and Column 2 ("Issued Patents"). A positive difference means that a larger percentage of the patents in the five largest patent families are computer architecture patents, while a negative difference means that a smaller percentage of the patents in the five largest patent families are computer architecture patents. A positive difference may indicate that computer architecture patents are more valuable or cover more significant patents while a negative difference may indicate that noncomputer architecture patents are more valuable or cover more significant patents.

The results in Table 3 show that there are five companies with a double-digit positive difference (AMD (46.5%), Via (33.4%), Qualcomm (30.2%), Intel (23.0%), and Renesas (14.5%)) and four companies with a double-digit negative difference (NXP (-31.5%), IBM (-29.7%), Microsoft (-29.0%), and Apple (-15.2%)). For the latter group of companies, the negative percentage for IBM and Microsoft may be due to the fact that those two companies are more software companies. As such, it is not particularly surprising that only a small fraction of their patents in their five largest patent families are computer architecture patents. For Apple, the 111 patents in the five largest patent families are categorized into 10 patent classes, only two of which are computer architecture classes. Of the 111 patents, 41 patents are categorized in the H04N patent class of the Cooperative Patent Classification System, which is entitled "Pictorial Communication, e.g., Television." The remaining patents in Apple's five largest patent families are categorized into other noncomputer architecture classes such as printed circuits, loudspeakers, and power distribution circuits.

Part of the reason why NXP's negative percentage is so large is because it does not have any computer architecture patents in its five largest patent families. Almost half of the patents in NXP's five largest patent families are directed towards amplifiers, while the remaining patents are directed towards categories such as "graphical data reading; presentation of data; record carriers; handling record carriers" and electric motors.

For the former group of companies, it is not particularly surprising that AMD, Via, Intel, and Renesas have a higher percentage given that a core part of these companies' businesses, at least historically, has been to design and sell microprocessors and microcontrollers. And given that a core part of Qualcomm's business is to design and sell systems on chip for wireless applications, it is also unsurprising that a higher percentage of its five largest patent families are computer architecture 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.

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