

Key technologies and international trends in EDA field of digital IC design: a patent analysis

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Abstract. Currently, Electronics Design Automation (EDA) software tools are highly monopolized internationally. In China, EDA suffers from the pain of "stuck neck". This paper will find out the key technologies in the EDA field through 3D sand table clustering algorithm, and analyze a series of patent data of monopoly three companies (Synopsys, Cadence, Mentor Graphic), in order to help local EDA enterprises perceive the technology status and development trend of the international EDA field.

1 Introduction

The Integrated Circuit (IC) industry and software industry are the key development areas of the "Made in China 2025" power strategy and the national innovation-driven development strategy^[1]. EDA as a software industry in the IC field, the importance is self-evident.

However, there is still a long way to go before the industry chain of chip manufacturing can truly achieve autonomy and control. The biggest difficulty in the field of chip manufacturing in China is the weakness in the manufacturing of lithography machine and the r&d and design of EDA software, which has been deeply stuck in the neck. EDA technology runs through the industrial software system of the entire integrated circuit industry chain. It is the most upstream and basic position of the industry chain, and plays an important strategic support role in design, manufacturing, packaging, testing, application and other links^[2].

At present, the EDA field of IC industry is in a highly monopolised state in the world, especially foreign enterprises Synopsys, Cadence Design Systems, Siemens EDA (Mentor Graphics) occupy nearly 80% of the market, referred to as the "three giants" in the industry. The three giants to a large extent control the EDA ecosystem, has formed a chip design chain upstream and downstream dependence^[3]. In the Chinese market, more than 95% of EDA software sales are held by the three giants. In other words, the analysis of the technology status of the big three can help us perceive the technology status of the entire EDA field. The overview of the three companies is shown in Table 1, and the international market share of the three companies is shown in Figure 1.

Therefore, through the patent map analysis of EDA's monopoly giants can help us understand the international market status quo and technology development trend, help

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local enterprises improve innovation competitiveness, strive to break import dependence as soon as possible.

Table 1. Introduction of EDA three giants.

Firm	Synopsys	Cadence	Siemens EDA (Mentor Graphic)
Founding time	1986	1988	1981
HQ	Silicon Valley	California	Oregon
Staves	13200+	~7600	~6000
Domestic employees	1200+	400+	~100
Turnover	\$ 3billion+	\$ 2.146billion	\$ 1.28billion
Star products	Polaris, DesignWare IP, Fusion	Tensilica DSP IP, Virtuoso	Calibre, Hyperlynx

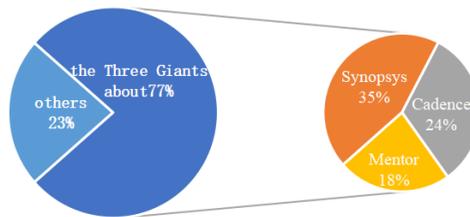


Fig. 1. EDA enterprises international market share of the composite pie chart.

2 EDA key technology topic identification

2.1 Data instruction

The research data from incoPat global patent database. The retrieval mode takes EDA and its subsidiaries as the applicant and transferee, retrieves multiple languages, retains the invention patent, filtering the utility model patent and design patent, and the application number is not merged. Retrieved time was held on 2020.12.20. And to perform the selective download of the patent writing entries.

2.2 3D sand table clustering

The 3D patent sand table is an advanced tool for patent strategy analysis [1]. The three-dimensional topographic map is used to vividly show the competition situation of technology. Wave peaks represent technology-dense areas and wave valleys represent technology blank points. Different colors are used to mark different patent applicants to clearly demonstrate the competition. Each dot represents a patent, and the closer the dot indicates a higher correlation of the technique. Compared with other theme clustering (LDA, etc.), the clustering algorithm of 3D sand table combines the characteristics of the patent itself, and is more professional and accurate for the clustering of technical keywords.

The intelligence analysis tool of incoPat patent database was applied to visualize the results in Figure 2. Synopsys in blue, Cadence in yellow, and Mentor in red. Line segment length corresponds to quantity proportion, the categories set to 6 and the labels set to 3. As the picture, the patents of EDA three giant enterprises are mainly clustered into five key technical themes: Verification, Simulation, Timing analysis, Layout wiring, and Synthesis.

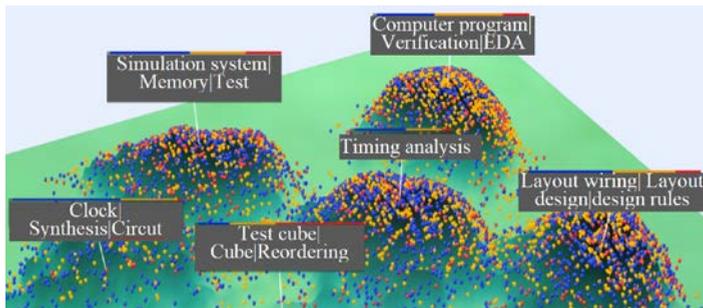


Fig. 2. The three giants patent 3D sand table clustering.

3 EDA patent analysis

3.1 Overall trend

Patent disclosure lag a certain. Generally invention patent is disclosed 3-18 months after the application. Thus this paper only analyzes the patent application trends. As shown in Figure 3., patent application-disclosure trends of the three giants from 2001-2020.

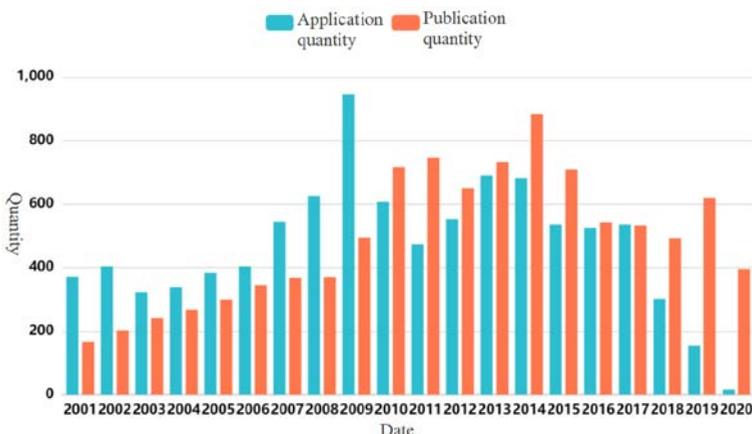


Fig. 3. The three giants patent overall application-disclosure trend.

From 2001 to 2009, under the background of the rapid development of chip industry, the number of patent applications of the company has increased rapidly. Synopsys became the world leading EDA tool manufacturer in 2008; In 2009- 2011, The number of patent applications has dropped slightly; From 2011 to 2017, The EDA field tends to mature in the integrated circuit industry; In 2017-2020, The number of patents applied has dropped significantly, High-level monopoly period in the EDA field, Technology development is saturated, It reflects that the overall situation in the EDA field of the international integrated circuit industry is not optimistic.

3.2 Technical composition analysis

The classification of the technical composition analysis is based on the IPC classification number. According to the more detailed characteristics of the EDA field knowledge system,

select the most detailed 'group' category, and the parameter is set to 20, before five as an example. Table 2. is available.

Table 2. Analysis of the patent technology composition of EDA three giants.

IPC Classification Number (Group)	Number
G06F17/50(CAD (The test circuit for static storage is designed into G11C29 / 54) (6,8))	6364
G06F9/455(Simulation; annotation; software simulation, (5,2006.01))	544
G01R31/28(Circuit test, (1,2006.01))	431
G03F7/20(Exposure and its equipment (4))	304
G01R31/3185(Test for the reconfiguration,e.g.LSSD, partition (6))	302

It can be concluded that the vast majority of the patents of the three giants belong to the G06F17/50 (CAD) classification, with a total of 6,364 patents, accounting for the highest proportion of 61.91%.

3. 3 Key technology distribution

The statistics according to the five technical themes of "verification", "simulation", "layout wiring", "timing analysis" and "synthesis", concluded the number and distribution of the EDA three giants' patents in various key technology fields. As shown in Table 3.

Table 3. Distribution of key technical topics of EDA three giants.

	Verification	Simulation	Layout wiring	Timing analysis	Synthesis
Synopsys	269	245	539	48	28
Cadence	291	243	496	49	15
Mentor	171	160	272	31	18
total	731	648	1307	128	61

From the perspective of enterprises, the distribution probability of EDA patents of the three giants on various topics is almost the same. The research results are the most among the five key technologies. Most of the researches of the three giants focus on the three technical topics of 'Verification', 'Simulation' and 'Layout wiring', and there are not many research and development on 'Timing analysis' and 'Synthesis', which intuitively reflects the EDA leading companies in various The degree of development, focus, and areas of expertise on technical topics are not very different.

From the perspective of technical topics, it can be seen that the number of researches on 'Layout wiring' is far ahead, and the development of EDA technology in this part has been very mature in the world; secondly, there are two technical themes of 'Verification' and 'Simulation' , the number of patents is only about half of 'Layout wiring', these two technologies are very difficult parts in EDA, it can be seen that there is still a certain research and development space; while the three giants have not done much research on 'Timing analysis' and 'Synthesis' two, indicating that there may be more gaps in the technical research and development of these two parts, existing a lot of room for innovation and development.

3.4 Technology life cycle

The analysis time span is from 2000 to 2020, results are shown in Figure 4.From the vertical axis, it can be seen that EDA technology was in the development period from 2000

to 2009, and in the mature period in 2009-2014. Since 2014, it has been a recession period (or a period of high monopoly). From the horizontal axis, it can be found that since 2007, the number of applicants has gradually decreased, indicating that the entire industry has gradually been monopolized, small companies have been acquired, and subsidiaries have been eliminated.

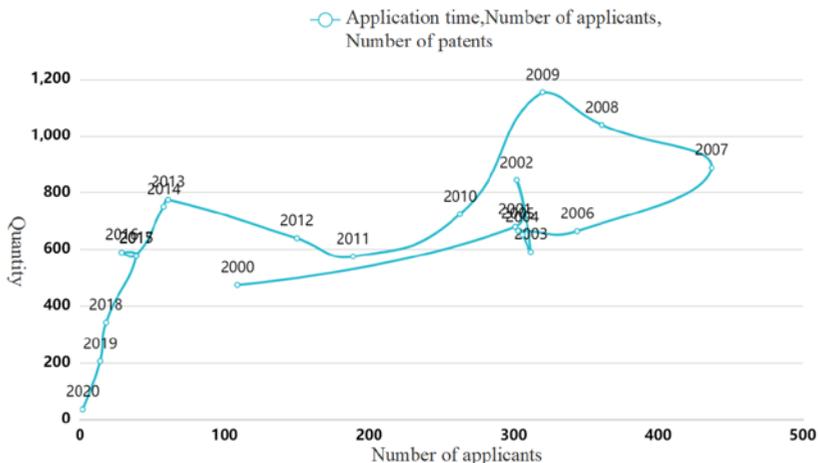


Fig. 4. EDA technology life cycle chart.

4 Summary

It can be seen from the above analysis that although EDA technology is monopolized by the Three Giants in the world, the overall development trend is not optimistic, and it is in an obvious bottleneck period. The research and development of key technologies is not comprehensive. There is still a lot of room for expansion in most technologies.

Therefore, under the positive policy environment that our country strongly supports the development of the integrated circuit and software industry, it is hoped that local EDA companies can seize the opportunity, strive to break through the "stuck neck" difficulty, take the best of them, and strive to be upstream.

References

1. Xincheng Wang, Xiaoyao Qi, and Bin Sun. "Design of Integrated Circuit Chip Fault Diagnosis System Based on Neural Network". Abstracts of the 6th International Conference of Pioneering Computer Scientists, Engineers and Educators (ICPCSEE 2020) Part I. Ed. , 2020, 57-58.
2. "Research and Markets; Global Markets for Engineering Software CAD, CAM, CAE, AEC, & EDA 2020-2027 - ResearchAndMarkets.com." Medical Letter on the CDC & FDA .(2020): doi:L. T. De Luca, *Propulsion physics* (EDP Sciences, Les Ulis, 2009)
3. "Computers - Computer-Aided Design; New Computer-Aided Design Study Findings Have Been Reported by F. Firouzi and Co-Researchers (Keynote Paper: From Eda to Iot Ehealth: Promises, Challenges, and Solutions)." Computers, Networks & Communications .(2019): doi: