

# Research on Cooperation Mode and Evolution Analysis of Huawei Company based on Patent Collaboration Network

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**Abstract:** Patents, as a vital tool in open innovation, play a significant role in enabling enterprises to access and utilize external resources, thereby enhancing their competitive advantage. This paper uses Huawei as a case study, employing patent metrics and social network analysis methods to examine the evolution characteristics and attributes of Huawei's collaboration network. The analysis, based on authorized patent data from the Incopat database, explores Huawei's collaboration mode. This study aims to provide insights and guidance for Chinese enterprises in the development and management of their patent collaboration networks. The findings reveal that Huawei adopts a mononuclear radiation cooperation mode, primarily industry-university oriented, with a focus on technological proximity.

**Keywords:** Social Network Analysis; Patents; Network Evolution; Industry-university-research Cooperation.

## 1. Introduction

Under the paradigm of open innovation, collaboration with other enterprises or organizations has become an essential means for businesses to acquire and utilize innovative resources. Patent technology collaboration is a significant avenue for open innovation in enterprises, enabling rapid industrialization of achievements and strongly facilitating the acquisition, absorption, and utilization of external resources.

As a leader in China's telecommunications industry, Huawei is highly active in patent activities and technological innovation, engaging extensively in patent-industry-academic research collaborations [1]. The existing research on Huawei primarily focuses on two aspects: the internationalization of research and development (R&D) and innovation modes. Liu et al. [2], using two indicators of R&D internationalization from the USTO database, analyzed Huawei's R&D mode, spatial distribution, and field distribution. Si et al. [3], taking Shenzhen Huawei Technologies Co., Ltd. as a case study and based on World Intellectual Property Organization patent data and corporate interviews, analyzed the pathways of Huawei's R&D internationalization. Hu et al. [4] examined the relationship between R&D internationalization and transnational knowledge networks and the innovation performance of R&D units, using panel data of Huawei's PCT patents. Wang et al. [5], by statistically analyzing the invention patent data of Huawei's Industry-university-research collaborations and using econometric methods, deduced the characteristics and evolutionary features of Huawei's patent Industry-university-research collaborations at different stages. Therefore, the research on Huawei's collaboration mode is not yet comprehensive.

A social network is a collection of actors in society as nodes and the relationships they form. In current research utilizing social network analysis to study innovation network cooperation modes and their evolution, Liu et al. [6] investigated the patent cooperation trends in China's SG field, the patent collaboration network, and the network's characteristics and structure.

Therefore, studying Huawei as the subject, based on authorized patent data to research technology network collaboration modes and their evolutionary patterns, can not only enrich the content of open innovation research but also provide insights and perspectives for exploring innovative cooperation modes based on network studies. This also holds practical value and significance by offering experiences for numerous technology enterprises in China.

## 2. Data Collection and Processing

This study sourced data from the Incopat global patent database, focusing on patents authorized and valid from 2003 to 2019 that are associated with Huawei. The collected patent information includes titles, applicants, publication dates, and International Patent Classification (IPC) codes. Following a thorough data cleaning process, a total of 33,919 valid entries were obtained.

## 3. Basic Characteristics of Huawei's Collaborations

### 3.1. Analysis of Collaborative Patent Numbers

Based on the variation in Huawei's growth ratio, the company's collaborative efforts are divided into four stages, as depicted in the Figure 1. The bars represent the annual change in the number of collaborative patents, while the line graph indicates the annual growth ratio of patent numbers.

**Stage 1: 2003-2010.** During this period, the growth ratio of Huawei's collaborative patents initially rose and then fell. However, the number of collaborative patents showed a trend of emerging from non-existence to steady growth, marking a period of patent accumulation.

**Stage 2: 2011-2013.** This stage coincides with the implementation of China's "12th Five-Year Plan." Driven by market demand, industry development, and government support, the new generation of information technology industry grew rapidly, leading to a further increase in Huawei's collaborative patent growth ratio. In this phase, Huawei accumulated patent technology, laying a solid

foundation for subsequent R&D.

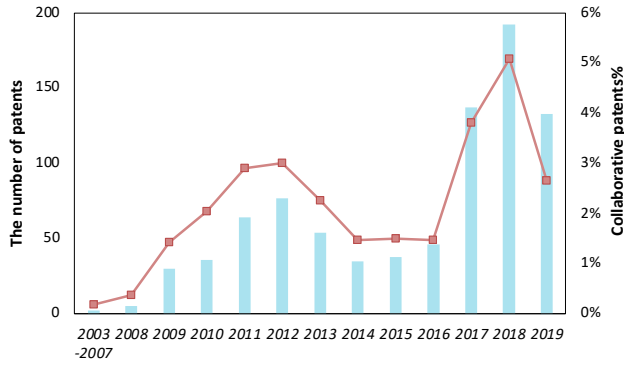


Figure 1. Annual distribution of Huawei's patents.

**Stage 3: 2014-2016.** The number of collaborative patents at Huawei decreased compared to the previous stages, with a slower growth rate, possibly due to strategic transformation. In 2016, Huawei proposed a strategic transformation that included shifting from purely interest-based relationships to cultural and value identification, from channel-based to solution-oriented business, from solely selling equipment to selling equipment with capabilities, and from meeting the needs of customers' office systems to addressing the requirements of production systems.

**Stage 4: 2017-2019.** Huawei's growth in patent collaboration slowed down, but the number of collaborative patents achieved a breakthrough, reaching a peak, marking a period of technological maturity. In 2018, Huawei's number of patents reached the highest in the world.

### 3.2. Evolution Analysis of Collaborative Partners

The analysis of Huawei's collaborative partners over recent years reveals that the company has engaged with businesses, research institutes, and universities. As shown in Figure 2, in the early years, Huawei predominantly collaborated with universities on patent technology. Over time, however, collaborations with universities have gradually declined. The collaboration with research institutes began to slowly increase in 2013, and by 2017, it surged, surpassing the trend of collaboration with universities. Literature indicates that in 2017, the Chinese Academy of Sciences assisted Huawei in technology cooperation and the development of 5G. As for collaborations with other businesses, although the proportion of patents is not large, the overall number has been on a slow upward trend.

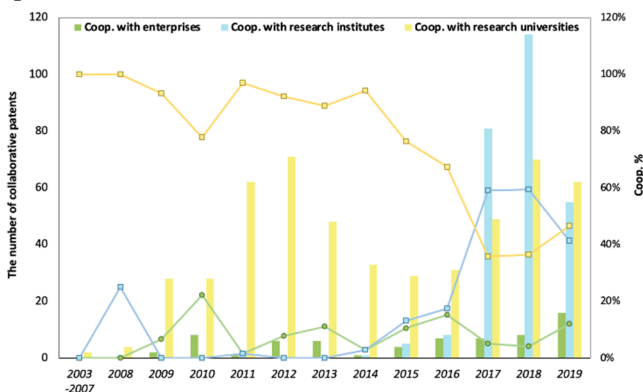


Figure 2. Classification and evolution of Huawei's collaborative partners

In summary, Huawei's collaborations are on an increasing trend, with a significant rise in the number of collaborations in the past three years. In the initial phase, universities were the primary collaborators. Subsequently, collaborations became more diversified, gradually shifting towards a focus on research institutes, with an increasing trend in collaborations with businesses.

### 3.3. Geographical Distribution of Collaborative Partners

Analyzing the geographical distribution of Huawei's collaborative partners reveals a concentration primarily in Beijing, Guangdong, and Jiangsu. Beijing accounts for the highest number of patent collaborations, which is associated with the location of key collaborative partners (such as the Institute of Computing Technology of the Chinese Academy of Sciences, Tsinghua University, etc.) in Beijing. This correlation also reflects the strong research and development capabilities of partners in the Beijing area. Therefore, to stay at the cutting edge of technology, Huawei transcends geographical boundaries to collaborate with top universities and research institutions, particularly those excelling in H04 (Telecommunication Technology) and G06 (Digital Information Processing). This approach demonstrates Huawei's technology-oriented collaboration mode.

Guangdong ranks second in the number of collaborative partners, which is related to the establishment of Huawei Technologies Co., Ltd. in Shenzhen. This reflects Huawei's geographical proximity and collaborative advantages in Guangdong Province. Jiangsu ranks third, linked to the establishment of a significant subsidiary of Huawei, Huawei Software Technology Co., Ltd., in Nanjing, and the strategic cooperation agreement signed with the Jiangsu Provincial Government in 2016. These patterns highlight Huawei's strategic inclination towards collaborating with technologically advanced and geographically significant partners to enhance its innovation and development.

## 4. Network Construction

### 4.1. Evolution Analysis of the Collaboration network

Using the collaborative patent data, Huawei's collaboration network is visualized with the aid of Gephi software. In this network, the size of nodes indicates the number of patents, while the thickness of edges represents the strength of collaboration between partners.

As illustrated in Figure 3, the structure of the company's collaboration network becomes increasingly complex with a growing number of collaborative partners. Core collaborating partners possess technologies pertinent to the company's key areas and have a significant influence on the company's development and technological control [4]. The primary collaborators vary across different stages, but Tsinghua University remains a core entity throughout. In the initial stages, the core partners include Shanghai Jiao Tong University, University of Electronic Science and Technology of China, Beijing University of Posts and Telecommunications, etc., mainly collaborating in the field of H04 (Transmission of digital information). In the fourth stage, the core collaborators include the Institute of Computing Technology of the Chinese Academy of Sciences and Tsinghua University, with the main technological collaboration area being G06F (Electronic digital data

processing).

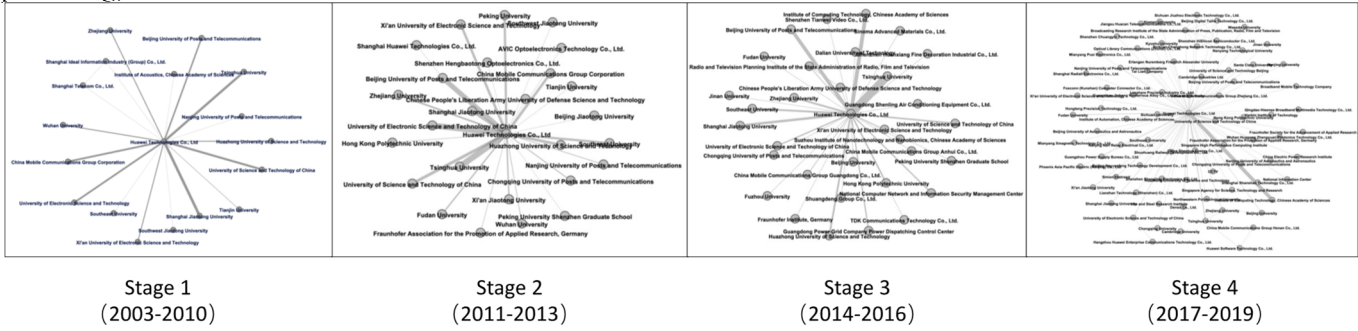


Figure 3. Huawei collaboration network evolution trend.

## 4.2. Analysis of Network Evolution Characteristics

The features of collaboration network are presented in Table 1. During the evolution, the scale and clustering coefficient of Huawei’s network increase, while the density decreases, indicating a clear evolutionary mechanism of preferential collaboration. The increase in average path length implies a reduction in the speed and efficiency of information flow within the network, leading to poorer knowledge fluidity.

Table 1. Characteristics of collaboration network.

	Stage 1	Stage 2	Stage 3	Stage 4
Network Size	18	27	33	81
Degree	18	26	33	94
Network Density	0.118	0.074	0.062	0.029
Average Path Length	1.882	1.994	1.938	2.28
Clustering Coefficient	0.669	0	0.667	0.765

## 5. Conclusion

The paper analyzes Huawei’s network structure and patterns using social network analysis, based on patent data from 2003 to 2020, and draws the following conclusions:

(1) Mononuclear Radiation Cooperation Mode. During the evolution of Huawei’s collaboration network, a mononuclear radiation pattern is observed, with Huawei Technologies Co., Ltd. serving as the absolute core. The cooperation between Huawei Technologies Co., Ltd. and research institutions or universities, characterized by technology sharing, forms the basis of this mode. The mononuclear radiation mode has strong stability and resilience to attacks, granting Huawei a dominant position in collaborations with centralized power. The concentration of human and financial resources makes connections with partners more convenient, reducing the cost of innovation.

(2) Industry-University & Industry-University-Research Oriented Cooperation Mode. Over the years, Huawei has primarily collaborated with universities, gradually evolving

into an industry-university-research mode in the fourth stage. Due to potential conflicts or threats like patent rights division and leakage of trade secrets among enterprises, collaborations with other companies have been relatively less. Collaborations with universities and research institutions, often possessing cutting-edge technologies, become an inevitable choice.

(3) “Technology-Oriented & Geographical Proximity” Cooperation Mode. Huawei’s most collaborations occur in Beijing and Guangdong, reflecting a mode combining technology orientation and geographical proximity. Although geographical proximity facilitates the acquisition and absorption of knowledge and technology, to access advanced technology, partnerships often transcend geographical constraints, prioritizing partners at the forefront of specific technological domains.

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