

A Study of Huawei's 5G Technology Innovation Ecosystem Based on Actor-Network Theory

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Abstract. The 5G technology enables a more comprehensive satisfaction of individuals' varied requirements by capitalizing on its improved information transmission efficiency and stronger signals. Investigating the innovative development of 5G technology contributes to enhancing network security and stability, thereby furthering enterprise digital transformation. This paper analyzes all 55 texts from the "News" section of Huawei's official website's 5G topic, which contain descriptions of Huawei's 5G innovation ecosystem. Building upon the actor-network theory, the study employs text coding to discern and classify actors and other elements that participate in the enterprise innovation ecosystem, and describes the collaborative network construction process with Huawei as the central actor. The study finds that heterogeneity in actor network theory plays an important role in the study of corporate innovation ecosystems. The four links of "Problematisation", "Interessement", "Enrollment" and "Mobilization" clearly describe the process of constructing a network of actors in STI activities. The actor network of Huawei's 5G technology innovation ecosystem is characterised by continuous openness and stable operation. Facilitating the digital transformation of the industry is the main reason for other actors to join Huawei's 5G technology innovation ecosystem actor network.

Keywords: 5G Technology Innovation, Actor-network theory, Innovation Ecosystem, Huawei.

1. Introduction

As a consequence of the swift advancements in information technology, 5G is progressively infiltrating diverse sectors of industry, commerce, and everyday existence, establishing itself as the standard for forthcoming developments. 5G can deeply integrate artificial intelligence, the Internet, and other fields, contributing to a comprehensive upgrade of traditional technologies. Simultaneously, its features including ultra-high speed, ultra-low latency, ultra-high reliability, and ultra-large connectivity deliver an enhanced user experience, accelerating the development of smart education, and smart cities, and empowering the digital economic development in our country, which ultimately contributes to the enhancement of the livelihoods and well-being of individuals. Consequently, how to better achieve innovation in 5G technology and accelerate its better application and exploration in various fields has become a pressing concern. This paper mainly introduces the text of the 5G topic on Huawei's official website, and analyses the innovation ecosystem of Huawei's 5G technology in combination with actor network theory.

2. Literature Review and Relevant Theories

2.1. Literature Review

In terms of innovation ecosystems, Moore, J. (1993) introduced a novel metaphor for competition, drawing inspiration from the study of biology and social systems, which marked the first application of the concept of ecosystems to the field of business. He suggested that in a business ecosystem, companies "co-evolve" around innovation, working cooperatively and competitively to support new products and satisfy customer needs [1]. The study of business ecosystems has since garnered continued interest. Moreover, in recent years, digital platforms have assumed a central role in the

global economy [2] (Bonina, C, 2021), the facilitation of effective promotion for digital platform development through corporate innovation has led to a renewed focus in recent literature on the study of enterprise innovation ecosystems. Comprehending the concept of the corporate innovation ecosystem, Grandstrand, O & Holgersson, M (2020) proposed a synthesized definition of an innovation ecosystem: An innovation ecosystem comprises a dynamic collection of entities, activities, and artifacts, as well as the institutions and relationships (including substitute and complementary ones), that are critical to the innovative performance of a particular entity or population of entities [3]. Gomes, LAD; Facin, ALF & Ikenami, RK(2018) identified a turning point in the literature, the transition from a business ecosystem to an innovation ecosystem. The business ecosystem is related predominantly to value capture, while the innovation ecosystem relates primarily to value creation [4]. Furthermore, DS (2016) and others have proposed that the concept of the innovation ecosystem overly emphasizes market forces, indicating a recommendation for caution in utilizing this term in research [5].

Regarding the impact of the enterprise innovation ecosystem under digital platforms on corporate development, Linde, L.; Sjodin, D.; and Wincent, J (2021) conducted a study investigating how firms can develop dynamic capabilities to orchestrate ecosystem innovation and, consequently, benefit from it. Besides, the research delved into insights concerning the dynamic capabilities and routines necessary for ecosystem innovation [6]. Additionally, Guo Aifang and others (2023), through the establishment of a system dynamics model, analyzed the substantial ramifications that the digital transformation of enterprise innovation ecosystems has attained [7]. Moreover, Ruan Tianshun and colleagues (2023) conducted an empirical analysis to examine how enterprises achieve digital innovation within the digital platform ecosystem, offering a theoretical framework for digital innovation in corporations [8].

Regarding Actor-network theory, it has also garnered substantial scholarly interest both domestically and internationally ever since its inception. Besides, as for its concept, actor-network theory, according to Martin M. (2015), identifies space and agency as the consequence of linking human and non-human entities in precarious wholes [9]. Martin, M & Schurr, C (2016) presume that actor-network theory proposed three cross-fertilisations that have implications for understanding three key processes in our socio-material world: stabilization, change, and affect [10]. Sayes. E (2014) assumes that the Actor-Network Theory is a controversial social theory. He aided readers in better comprehending what it implies to assert, using Actor-Network Theory, that nonhumans exert agency, which aimed to help readers more precisely evaluate and decide whether to reject or accept the Actor-Network position, clarifying the specific considerations involved in this decision [11].

Actor-network theory is a highly significant theoretical resource that is currently applied in the study of enterprise management patterns and their influence on corporate development. Anete, A. (2023) and others proposed a connection between stakeholder theory (ST) and Actor-Network Theory (ANT) to provide a more detailed explanation of the dynamics of actors in the sector, particularly in the context of socio-technical transitions toward sustainability [12]. Moreover, Gao Xuexian and colleagues (2020), utilizing an ANT perspective, researched the implementation path of corporate strategic transformation, indicating that the process of corporate strategic transformation is essentially the process of key actors constructing actor networks [13].

In terms of conducting research on corporate innovation ecosystems based on actor networks, Chu Jiewang et al. (2023) researched heterogeneous subjects in the knowledge transfer of enterprise innovation ecosystems by describing the construction phases of the Enterprise Innovation Ecosystem [14]. Other more systematic studies are relatively lacking. Other more systematic studies are relatively lacking. Dai Xiangyang and Cai Zhong (2022) studied the innovation process of Huawei's 5G technology based on actor network theory, theoretically illustrating the relationship between technological innovation and openness [15]. However, their study did not address the heterogeneity of actors and the construction process of actor networks under this theory. Therefore, this paper would like to focus on Huawei's R&D of 5G technology as an in-depth analysis of Huawei's 5G technology innovation ecosystem based on actor network theory.

2.2. Actor-network-theory

The Actor-Network Theory, frequently referred to as the “Sociology of translation”, is a sociological analytical method proposed by French sociologists Bruno Latour, Michel Callon, and John Law. The focal points of this theory comprise actors, translation, and networks, among other concepts. The term “actor network” is defined as a process that is instigated by core actors and entails the involvement of other actors, with the collective objective of attaining particular goals and fulfilling the interests of multiple parties. An actor is anything that alters the state of things by making a difference, encompassing both human actors like individuals and organizations, as well as non-human entities and forces. Translation involves how network builders attract potential actors to converge various entities into a commonality, and the network refers to framing and summarizing the interactions and relationships between actors in a localized, practical, and focused system [16].

Translation is the core of the Actor-Network Theory. The theory posits that although translators may alter and distort the original intentions of others, the connection of actors is formed through translation, resulting in an actor-network. The translation process consists of four stages: Problematization, where core actors and obligatory passage points (OPP) are established; Interessement, involving the analysis of obstacles and interests of all actors, with core actors allocating corresponding benefits based on the goals of other actors; Enrollment, attracting other actors; Mobilization, organizing other actors to form interest alliances and efficiently fulfill their roles. This paper, drawing on the Actor-Network Theory, analyzes the Huawei 5G innovation ecosystem in terms of actor identification, translation processes, and network forms.

3. Case Selection and Data Collection

3.1. Case Selection

Huawei is the subject of this paper’s case study. Huawei Technologies Co., Ltd., founded in 1987, is a leading provider of solutions for information and communication technologies on a global scale. Huawei was ranked number 96 on the 2022 *Fortune* Global 500 and occupied the top spot on the 2020 China Top 500 Private Enterprises.

The choice of Huawei for this study is based on several considerations. In the first place, the representativeness of the company case: Huawei has devoted years of research to 5G innovation, establishing an integrated framework of cloud platforms, industry applications, as well as smart terminals, receiving world attention for its achievements. Secondly, the relevance of the research content: Huawei has consistently invested substantial efforts in the 5G domain, focusing on the innovation and development of 5G. The significance of this commitment extends beyond the realm of 5G enterprise innovation ecosystem development research. Thirdly, the accessibility of data: As a global technology giant, Huawei provides abundant resources, including company annual reports, executive speeches, business reports, and numerous publications, facilitating comprehensive data acquisition.

3.2. Data Collection and Compilation

Huawei’s official website’s “News Centre” introduces Huawei’s development history and innovation research on 5G technology, with three columns, “Partnerships”, “Performance and Strategy” and “R&D Breakthroughs” providing more detailed descriptions of Huawei’s 5G innovation activities in recent years, as well as an introduction to other participants in Huawei’s 5G innovation ecosystem. The three columns of “Partnerships”, “Performance and Strategy”, and “R&D Breakthroughs” provide a more detailed description of Huawei’s innovation activities in 5G in recent years, as well as an introduction to other participants in Huawei’s 5G innovation ecosystem. Therefore, this article focuses on the data sources of “Partnerships”, “Performance and Strategy”, and “R&D Breakthroughs” in the “News Centre” column of Huawei’s official website. This paper focuses on the news information under the topic of 5G in the columns of “Partnerships”, “Performance and Strategy”,

and "R&D Breakthroughs" in the "News Centre" of Huawei's official website, and ultimately generates 55 valid text materials and 695 valid statements. At the same time, this paper also tries to collect effective text information about actors and STI activities in Huawei's 2022 annual report and related academic literature, which together serve as a supplement to the information in this paper.

Based on the concept of actor-network-theory, this paper conducts theoretical coding and textual analysis focusing on "actor identification" and the translation process, encompassing four elements: "Problematisation", "Interessement", "Enrollment", and "Mobilization". The data content is initially broken down, organized, and summarized to form primary codes (as detailed in Table 1). The content of primary codes is then summarized, and key terms are extracted for secondary coding. By further generalizing and merging key terms from the secondary coding, valuable information is extracted for the purpose of tertiary coding.

Table 1. Coding of Case Data

Data Source	Code				
	Actor identification	Problematisation	Interessement	Enrollment	Mobilization
Data Obtained from the "News" Column consisting of 55 pieces of information	A1	P1	I1	E1	M1
Information obtained from other channels including corporate annual reports and others	A2	P2	I2	E2	M2

4. Identification and Analysis of Actors in the Huawei 5G Technology Innovation Ecosystem

4.1. Coding Analysis of Key Innovation Actors in the Huawei 5G Technology Innovation Ecosystem

Huawei possesses a highly diverse 5G technology innovation ecosystem, where participants interact with each other, collectively propelling the growth of the 5G technology industry. Based on the collection of 55 pieces of data, this paper focuses on 58 key innovation activities within the text. Through text coding, the identification of actors involved in the crucial innovation activities is conducted (refer to Table 2).

Table 2. Identification of Actors in Innovation Activities

Examples of Typical Quotations	Primary coding	Secondary coding	Tertiary coding
Huawei, in collaboration with Changping Laboratory, Peking University's Biomedical Pioneering Innovation Center (BIOPIIC), the College of Chemistry and Molecular Engineering, Professor Gao Yiqin's research group at the	A1	Huawei, Changping Laboratory, Peking University's Biomedical Pioneering Innovation Center (BIOPIIC), the College of Chemistry and Molecular Engineering, Professor Gao Yiqin's research group at the Shenzhen Bay Laboratory, and	Enterprise, research institutions, developers, technology

Shenzhen Bay Laboratory, and Professor Chen Jie's team at Peng Cheng Laboratory, developed a protein structure prediction model based on the comprehensive AI framework, MindSpore, achieving outstanding results (ranked 1st globally) in the Continuous Automated Model Evaluation (CAMEO) competition, a continuous global competition for protein structure prediction. (25-3).....		Professor Chen Jie's team at Peng Cheng Laboratory collaborated on the development of a protein structure prediction model.	
The Henan Provincial Government and Huawei Technologies Co., Ltd. have signed a comprehensive and deepened strategic cooperation agreement. In accordance with the principles of “complementary advantages, voluntary equality, open fairness, and mutual benefit”, both parties will promote the development of Huawei's industries and related businesses in Henan. The cooperation will focus on areas including computing, artificial intelligence, digital energy, intelligent connected vehicles, and digital government construction. Additionally, leveraging the experience and technological accumulation in the construction of the digital economy and new infrastructure, the collaboration aims to accelerate the digital transformation of cities and industries. Regarding industrial ecology, efforts will be ongoing to advance the construction of the Henan Provincial Industry Research Institute, expedite the establishment of provincial-level industry research institutes, and set up industry research centers in various cities. This collaboration aims to accelerate the digital development of industries in Henan through technological innovation (31-12).....	A1	The Henan Provincial Government and Huawei Technologies Co., Ltd. have signed a comprehensive and deepened strategic cooperation agreement. This collaborative effort entails the formation of industry research centers in multiple cities, the Henan Provincial Industry Research Institute, and industry research institutes at the provincial level. By leveraging technological innovation, this partnership seeks to accelerate the digital transformation of industries in Henan.	Enterprise, government, research institutions, technology

Collaborating with global operators and partners, Huawei accelerates digital transformation to contribute to the business success in the 5G era. As of the conclusion of 2022, the number of 5G users worldwide has surpassed one billion. The 5G networks constructed by Huawei maintain a consistently leading user experience. Simultaneously, Huawei actively collaborates with the industry to collectively define the concept of 5.5G, fostering the ongoing development of the connectivity industry (40-2).....	A2	Global operators, partners, and a global 5G user base exceeding 1 billion.	Enterprises, users
In 2022, Huawei's research and development expenditure amounted to approximately 161.5 billion Chinese Yuan, accounting for 25.1% of the total annual revenue. The company established 86 basic technology laboratories, enhancing the corresponding core technology systems. In the wireless field, Huawei collaborated with the global industry to explore and define 5.5G, advocating a comprehensive transition to the 5.5G era and promoting the continuous evolution of ICT infrastructure. In the field of AI, Huawei released the OptVerse AI Solver to meet the high-dimensional optimization needs of complex problems across various scenarios. Regarding software ecology, the company continued to embrace open source initiatives, working with partners to promote the prosperity of the Euler and HarmonyOS open-source ecosystems. Together, they aim to create an open-source operating system covering future computing scenarios, providing the world with another choice (55-21).....	A2	In 2022, research and development expenditures amounted to approximately 165.1 billion Chinese Yuan. Huawei established 86 basic technology laboratories, refining the associated core technology systems. The organization, in conjunction with its partners, actively advocated for the growth and development of the open-source Euler and HarmonyOS ecosystems.	Enterprise, research institutions, technology, funding

4.2. Analysis of Categories and Characteristics of Actors in the Huawei 5G Technology Innovation Ecosystem

Through the identification of actors in the Huawei 5G Technology Innovation Ecosystem, a further categorization and frequency analysis of the actors were sorted out (refer to Table 3). This study determined that in the actor network of the Huawei 5G Technology Innovation Ecosystem, the human actors involved primarily include enterprises, research institutions, financial institutions, developers, government, as well as users. Non-actors predominantly include funding, technology, and commodities.

Table 3. Actor Categorization

Actor Name		Actor Description	Actor Examples	Key Partners and Frequency of Occurrence
human actors	Enterprises	Enterprises are the primary actors in the Huawei 5G Technology Innovation Ecosystem, including core enterprises and their collaborations with 5G network operators, 5G device manufacturers, and other high-tech enterprises.	Core Enterprises: Huawei 5G Network Operators: China Unicom, China Mobile, China Telecom, Telkomsel 5G Device Manufacturers: HiSilicon Technologies, BoE Optoelectronics High-Tech Enterprises: Xiaomi, China Electronics Corporation, Nokia	China Unicom (6 occurrences), China Mobile (12 occurrences), China Telecom (6 occurrences)
	Institution	Research institutions consist primarily of universities and research institutes, which integrate their own knowledge and technology into the innovation ecosystem in addition to providing high-tech contributions to it.	Universities: Shenzhen Polytechnic University Research Institutes: China Academy of Information and Communications Technology, China Electric Power Research Institute	China Academy of Information and Communications Technology (5 occurrences)
	Financial Institution	Financial institutions are eligible to participate in the innovation ecosystem if they share common interests, strive to achieve mutual benefits, or encounter comparable risks and challenges. Ultimately, this results in a cooperative and mutually beneficial relationship among the components of the ecosystem.	African banks	
	Developers	Developers primarily refer to individuals working in the core technology laboratories of enterprises or high-tech professionals who operate independently from the enterprise.	Shenzhen Bay Laboratory, Peng Cheng Laboratory	

	Government	Governments, to enhance regional development, can acquire technological and informational access by joining the innovation ecosystem.	The Henan Provincial Government	
	Users	Users, as the primary recipients and users of knowledge, contribute substantially to the innovation ecosystem.	Huawei Mobile, consumers in automotive and other	
nonhuman actors	Funding	Enterprise collaboration, technology research and development, promotion of goods, and numerous initiatives all require financial investment. Financial support is an essential element within the innovation ecosystem.	Funds for scientific research	
	Technology	Technological research and development, continuous innovation, patent licensing, and certification play a significant role in the continuous operation of enterprises. The development of businesses is inseparable from technology.	Audio-video technology, and the ten-grade variable aperture used for smartphones.	
	Products	Companies and partners achieve technology exchange through tangible and intangible goods, promoting collaborative development.	Cell phones, automobiles	

Through an analysis of actors within the Huawei 5G Innovation Ecosystem, this paper reveals a relatively large number of actor types in Huawei's Actor-network. The frequency of cooperation with China Mobile, China Telecom, China Unicom, and the China Academy of Information and Communications Technology is the highest among all actors. In recent years, they have consistently expanded their businesses, collaborated with Huawei on multiple occasions to drive the development of the new communication industry, and released projects including the "5G Power Virtual Private Network Network Security White Paper". They have reached a consensus on interests with Huawei in various events, gradually establishing a solid position in Huawei's 5G Innovation Ecosystem's Actor network. As key partners of Huawei, they actively contribute with their abundant experience and high technical proficiency, proposing initiatives, participating in other projects, leading other enterprises to join Huawei's Actor network, and advancing 5G network technology as a whole into an unprecedented era.

4.3. Analysis of Human Actors Composition in Huawei 5G Technology Innovation Ecosystem

The Enterprise Innovation Ecosystem is a multi-layered, multi-dimensional collaborative innovation system formed by numerous potential innovation entities and resources. Based on the "Government (public institutions) – Enterprise (industry) – University Research – Users (citizens)" Quadruple Helix innovation-driven model [17], and combining the actor analysis of Huawei's 5G innovation ecosystem mentioned above, we can further analyze the composition of human actors in

Huawei's 5G innovation ecosystem. Supported by non-human actors including funds, technology, and goods, Huawei, as a core enterprise, engages in ongoing resource sharing with human actors in the innovation ecosystem, thereby accelerating the advancement of 5G technology. The Huawei 5G Technology Innovation Ecosystem comprises human actors comprising primarily 5G network operators, manufacturers and suppliers of 5G devices, high-tech enterprises, effective research institutes, governmental entities, and users.

(1) 5G network operators. Huawei has established a strong supply chain partnership with domestic and international telecommunications providers in recent years, prioritizing collaboration with these companies. China's three major operators—Mobile, Telecom, and Unicom—are key partners for Huawei, fostering close collaboration. They have jointly released white papers on 5G technology with Huawei, initiated projects including the F5G Industry Evolution and Development Initiative, and worked together to accelerate the rapid development of 5G. Besides, operators are expediting the innovation of 5G technology applications, covering hotspots with 5G network deployment, and collaborating with 5G enterprises to analyze customer needs, comprehend market dynamics, make precise decisions, and promote coordinated development.

(2) Device manufacturers and suppliers. Huawei prioritizes supplier specialization in its global search for high-quality partners in order to capitalize on its strengths and prevent weaknesses. By fortifying alliances with exceptional suppliers, Huawei expedites the transformation of the worldwide supply chain. Huawei increased its commitment to a green supply chain in 2020 by implementing emission reduction projects and completing 100 percent carbon emission data reporting among the Top 100 suppliers. Huawei and its suppliers engage in collaborative efforts aimed at advancing the intelligent era.

(3) High-tech enterprises. Through collaboration with high-tech enterprises, Huawei leverages mutual strengths to drive industries towards intelligence, achieve its goals, and propel 5G development. For example, Huawei collaborates with leading companies in artificial intelligence including GrinGlint, DeepTuring, and AnswerBook, advancing the innovation and development of the Ascend AI industry. The objective of global cross-licensing agreements encompassing 5G standards, which involve companies including Xiaomi and OPPO, is to foster a sustainable and enduring intellectual property ecosystem.

(4) Efficient research institutes. Laboratory research has consistently been a central tenet of conventional innovation theory, as it is an indispensable component of technological innovation for businesses. Huawei has consistently placed emphasis on the cultivation of talent and technological advancement by establishing research laboratories in multiple universities and fostering close collaborations with research institutions. As a strategic partner of Huawei, the China Academy of Information and Communications Technology actively engages in collaborative efforts to identify and develop cutting-edge research technologies and high-tech talent.

(5) Government. Currently, digitization and intelligence serve as the driving forces and breakthroughs for the revitalization of the manufacturing industry. The development of the digital industry, the promotion of digital empowerment, and the concerted effort to achieve a "two-way convergence" between the digital economy and the real economy are key priorities. Huawei, equipped with cutting-edge technology and a pool of high-tech talents, has been actively collaborating with the government in recent years to build digital cities and propel urban development.

(6) Users. Under the influence of consumer demands, businesses develop an innovative ecosystem that satisfies the needs of both customers and partners. In response to shifting market conditions and consumer preferences, Huawei satisfies user requirements through the introduction of various product series, thereby establishing a steady and sizable user base.

5. The Network Construction of Huawei’s 5G Technology Innovation Ecosystem During the Translational Process

5.1. Text Mining Analysis of the Translated Section

In the process of constructing the Huawei 5G Technology Innovation Ecosystem, “translation” serves as a crucial “catalyst” between actors and the network, playing an essential role. Its intrinsic logic is reflected in the core actors establishing “mandatory passage points”, enabling them to attract other actors by reaching a consensus on interests, providing technical support, and other means. They collectively finalize the infrastructure of the actor network. This research investigates and assesses assertions pertaining to the “translation” segment of the text, differentiating the four elements of “problematization”, “interestment”, “enrollment”, and “mobilization” that transpire throughout the “translation” procedure, using a compilation of 55 documents as its basis. In the translation of the Huawei 5G Technology Innovation Ecosystem, illustrations of typical quotations and their corresponding coding are presented in Table 4.

Table 4. Examples of Typical Quotations and Coding in the Translation

Actors		Examples of Typical Quotations	Primary coding	Secondary coding	Tertiary coding
human actors	Enterprises	Both parties have jointly established the first 5G lighthouse factory nationwide, collaborating on the development of four main themes and nine application scenarios, including AI quality inspection on the production line. Huawei aims to replicate this success with more customers alongside telecom partners. Targeting mid-market customers, Huawei will prioritize a partner-centric approach, using shared interests to build a partner-driven market system. Huawei looks forward to deepening cooperation in such markets with Guangdong Telecom. (13-7).....	M1	Using shared interests as the linchpin, we aim to build a partner-driven market system.	Increasing market penetration and revenue.

	Research Institutions	China Mobile Research Institute, along with industry partners including Huawei, jointly released the “5G New Calling Technology White Paper”. The objective is to provide technical references and guidance for implementing 5G new calling features on platforms, terminals, and chips. The initiative calls for collaborative planning and research and development of related products among industry stakeholders to promote the development of 5G new calling services. (27-15).....	I1	Providing technical references for the 5G new calling features and promoting the development of 5G new calling services.	Additional research and planning are required to develop products that incorporate the new calling features of 5G technology.
	Financial Institutions	Huawei is calling for collaboration between the Information and Communication Technology (ICT) industry and the banking sector to collectively address challenges including “online service instability” and the risk of virus intrusion in banks. The aim is to propel the African banking industry towards a direction characterized by “uninterrupted service”, “uninterrupted business”, and	E1	Drive the African banking industry towards the direction of “uninterrupted service”, “uninterrupted business”, and “uninterrupted innovation”.	Jointly tackle challenges and contribute to the development of the banking industry.

		“uninterrupted innovation”. (11-8).....			
	Developers	Ascend AI’s industrial development is progressing rapidly, laying the intelligent foundation for thousands of industries. Ascend has already cultivated a community of over 1.2 million developers and collaborated with more than 1,000 Independent Software Vendors (ISVs) to launch over 2,000 AI solutions across various industries. (34-11)	M2	Introducing industry-specific AI solutions.	Facilitating the rapid development of the Ascend AI industry.
	Government	Henan is a major province in traditional manufacturing, with a rich foundation in supporting industries and broad market prospects. However, addressing concerns pertaining to enterprise transformation, upgrading, and brand enhancement is of the utmost importance. (19-9).....	P1	The urgent need to address issues related to enterprise transformation, upgrading, and brand enhancement.	Boosting regional GDP.
	Users	In the past, the hotel encountered challenges during high-volume tourist periods, which diminished the overall experience for patrons. These challenges	P1	Issues including slow internet, lack of network connectivity in certain areas, and delayed responses from the front desk	Enhancing user experience.

		encompassed slow internet speeds, unreliable network connectivity in specific areas, and prolonged response times from the front desk check-in system. (30-12).....		check-in system have occurred.	
nonhuman actors	Funding	Huawei adheres to a strategy of co-creation, sharing, and win-win, focusing on developers in numerous work scenarios including software and hardware design, development, testing, release, and operation. The company consistently expands technological openness, enriches toolchains, optimizes experiences, shares industry expertise, increases financial support, and comprehensively supports developers for success. Huawei has accumulated and served a community of 9 million developers. (42-21).....	M2	Increase financial support.	Empowering developers for success.
	Technology	A patent pool can assist enterprises in licensing patents, allowing them to reinvest licensing revenues into further innovation. This is particularly crucial for small and medium-sized enterprises. Huawei looks forward to the successful operation	E1	Attracting more enterprises to invest in the research of next-generation Wi-Fi technologies, assisting in patent licensing, and reinvesting licensing revenues into further innovation.	Empowering enterprises in the development of patent technologies.

		of the patent pool, which can attract more enterprises to invest in the research of next-generation Wi-Fi technologies. (37-13).....			
	Commodities	Full-optical eEnterprise Networking is a full-optical FTTR enterprise networking product jointly launched by China Mobile and Huawei. Based on Huawei's FTTR-B solution, it provides small and medium-sized enterprises with ultra-gigabit full-optical networking. It is currently widely used in scenarios including hotels and shops. Huawei's FTTR-B devices use flexible tri-mode antennas and support various installation methods including ceiling-mounted and wall-mounted, achieving indoor full-area Wi-Fi coverage, enabling users to experience the optimal network from any location. (53-5).....	M1	The product has a wide range of applications, enhancing the user experience.	Gradually increasing market share.

Regarding the research on the Actor Network construction process of the Huawei 5G Technology Innovation Ecosystem, this paper is based on the collection of 55 reported materials, organizing key statements related to the translational part in the Actor-Network-Theory. A total of 129 effective statements were summarized. Among them, 34 statements were involved in the problematization stage, 60 statements in the interessement stage, 16 statements in the enrollment stage, and 19 statements in the mobilization stage. The principal specific issues and frequencies associated with the translational process throughout the four stages are outlined in Table 5.

Table 5. Main Specific Issues and Frequencies in the Translational Process Across Stages

	Specific Issues	Main Actors Involved	Frequency
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Problematization Stage	The digital market faces significant opportunities and substantial challenges in space.	Enterprises, government, research institutions, and financial institutions.	8 occurrences
	The demand for intelligence has significantly increased.	Enterprises, products, users.	3 occurrences
Interessement Stage	Facilitating the industry's digital transformation.	Enterprises, government, research institutions.	16 occurrences
	Enhancing customer experience.	Enterprises, users, commodities.	4 occurrences
	Facilitating the industry's transition to intelligence.	Enterprises, government.	4 occurrences
	Building a prosperous and sustainable Ascend ecosystem.	Enterprises, technology.	3 occurrences
Enrollment Stage	Calling on all sectors of the industry to jointly promote industrial development.	Enterprises, research institutions, financial institutions.	3 occurrences
Mobilization Stage	Reaching patent licensing agreements with enterprises to provide consumers with more competitive products and services.	Enterprises, technology.	5 occurrences

This paper finds that, during the problematization phase, a multitude of stakeholders within Huawei's 5G innovation ecosystem is primarily preoccupied with strategies to accelerate the development of intelligence and confront the substantial challenges and opportunities that exist in the current digital market. This underscores the central position of digital platforms in today's world economy. In the interessement phase, the main goal of various actors continues to focus on how to assist in the industry's digital transformation and promote intelligent development. Based on their different research areas, various actors also have their main interests. For example, enterprises oriented toward user demands join the actor-network primarily to enhance the user experience, while technology companies leading in artificial intelligence aim to build a prosperous and sustainable Ascend ecosystem. Various stakeholders actively solicit collaborative endeavors in industry advancement during the enrollment phase, thereby assisting Huawei in establishing an expanding network of interest communities. High-tech companies that have entered into patent licensing agreements with Huawei provide the most significant feedback during the mobilization phase. This enables these companies to offer consumers products and services that are more competitive in nature. The imperative for enterprises to attain a competitive edge and expand their market presence is indisputable: innovation in products and services is predicated on technological advancements.

5.2. Translation in actor-network-theory

Translation, as the core of actor-network-theory, encompasses four parts: "problematization", "interessement", "Enrollment", and "Mobilization", which clearly describe the construction process of the Actor-network. Among them, the "problematization" and "interessement" stages are closely related, with other actors attempting to solve problems after identifying them. This allows them to establish common goals and achieve interest alliances with the core actors. Consequently, this paper combines "problematization" and "Interessement" into one point, analyzing the translation process from three perspectives in the construction of Huawei's 5G Technology Innovation Ecosystem's Actor network.

(1) In the "problematization" and "Interessement" stages: Define the mandatory passage points precisely and establish the actors' interest associations.

It is the initial stage of translation for the key actors to identify the primary issues and challenges, with a particular emphasis on the mandatory passage points. The key is to first clarify the status of the core actors, and the core actors should have the ability to identify, summarize, and solve problems, establishing feasible compulsory passage points to ensure the effective completion of each subsequent step. This study found that Huawei, as the core actor in the actor-network, with its leading position in the field of 5G technology, can effectively play an organizational role, gaining the trust and support of other actors. At the same time, Huawei can accurately identify the problems of other actors, establish different solutions for different actors, clearly define the compulsory passage points to achieve common goals, and convince other actors that joining the compulsory passage points set by the core actor can effectively solve current problems and achieve expected benefits. (Figure 1)

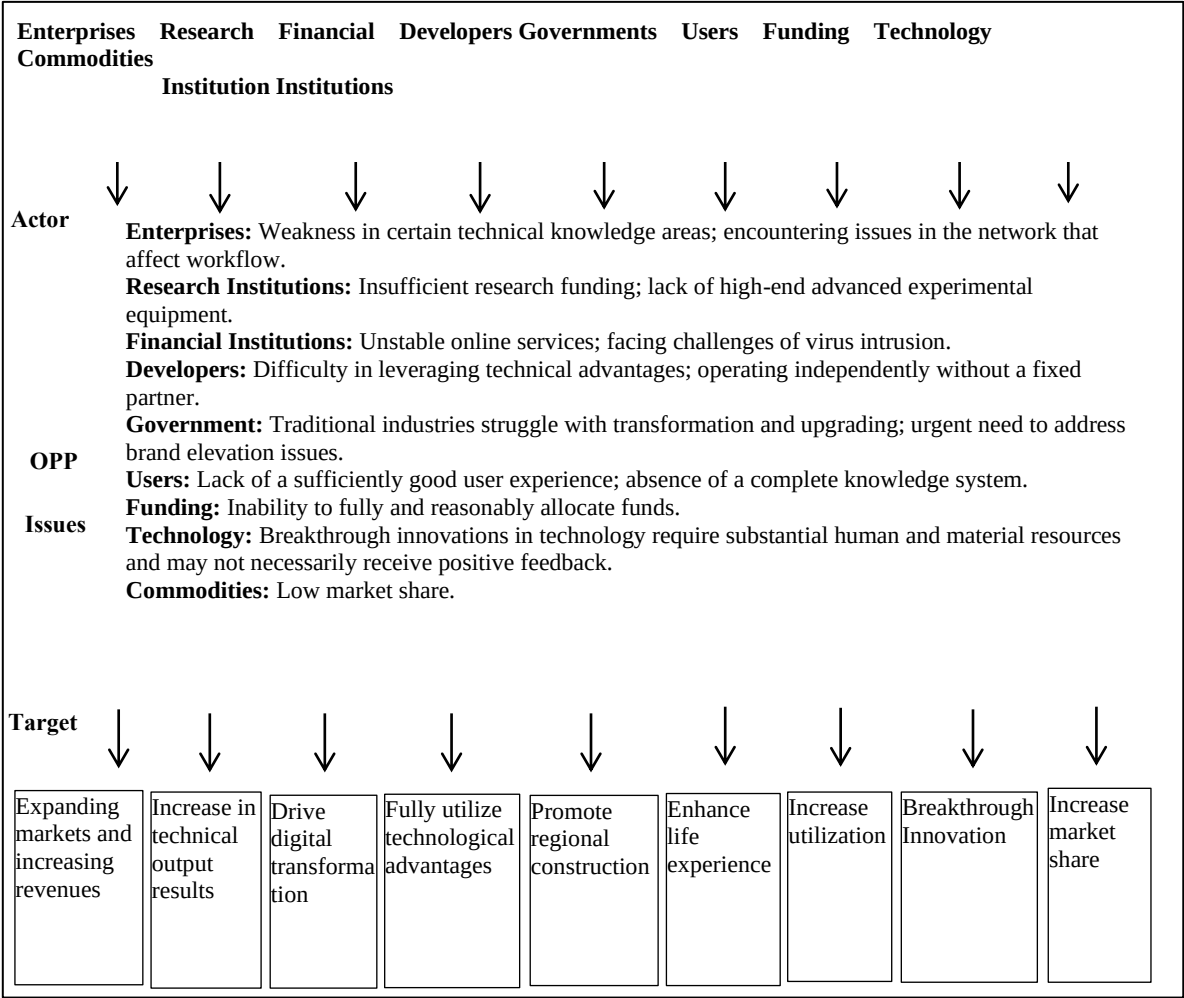


Figure 1. Obstacles and Interests of Various Actors in Huawei's Innovation Ecosystem

(2) Enrollment Stage: Seeking Common Interests

This stage involves the core actor establishing a multi-layered network structure, defining roles for actors, and implementing mechanisms to control potential conflicts. The core actor, in this case, Huawei, as the central figure in the actor network, strategically leverages its keen focus and exploration of 5G technology. Actively collaborating with research institutions and financial organizations, Huawei expands its product business and gradually enlarges the industry's scale. Actively seeking 5G technology developers and establishing a patent pool to support enterprise patent research, Huawei consistently attracts more actors to participate in the research of 5G technology. By contributing knowledge to the entire system, the enterprise facilitates the formation of a consensus among diverse parties regarding their interests, allowing them to capitalize on their strengths. With the continuous maturation of technology, ongoing improvements in product development, and a steady increase in market share, Huawei identifies an increasing number of common interest

communities, collectively contributing to the digital transformation of the industry within the actor network.

During the “Interessement” stage, Huawei, as the core actor, effectively utilizes its role, setting industry standards and influencing specific activities through its leading position and innovative technology. Additionally, Huawei maximizes the positive impact of its key partners, relying on their stable position within the actor-network. These key partners jointly act as knowledge contributors, continually attracting more actors and enhancing the scale of the actor network.

(3) Mobilization Stage: Establishing a Stable Actor Network

At this juncture, the central actor consolidates and organizes diverse resources to establish a robust actor-network. Huawei, being a frontrunner company in the realm of 5G technology, efficiently assimilates and distributes expertise, thereby enhancing the Actor network’s overall stability. Financial institutions and research institutions each fulfill their specific functions, thereby consistently augmenting market penetration and revenue generation. Developers overcome technical challenges, leveraging their technological strengths. Huawei contributes to regional GDP growth, while the government implements policies to boost the development of the 5G industry. Huawei consistently increases financial investment, focuses on technological innovation, and collaborates with other actors to achieve breakthroughs. As Huawei removes barriers for other actors to enter this network, ensuring their enthusiasm, it attracts an increasing number of new types of actors. These actors play their roles effectively, collectively promoting the formation of a more stable Actor-network.

During the enrollment stage, Huawei efficiently organizes all actors in the actor-network, providing ample opportunities for resource exchange and enhancing collaborative innovation activities among enterprises. By maintaining an open actor-network, reducing entry barriers, and fostering a flexible development environment for all actors, Huawei accommodates various new types of actors, enriching the network structure and gradually establishing a stable actor-network.

5.3. The Actor Network in Huawei's 5G Technology Innovation Ecosystem

Through the four translational stages mentioned above, this paper constructs the Actor Network of Huawei’s 5G Technology Innovation System (refer to Figure 2).

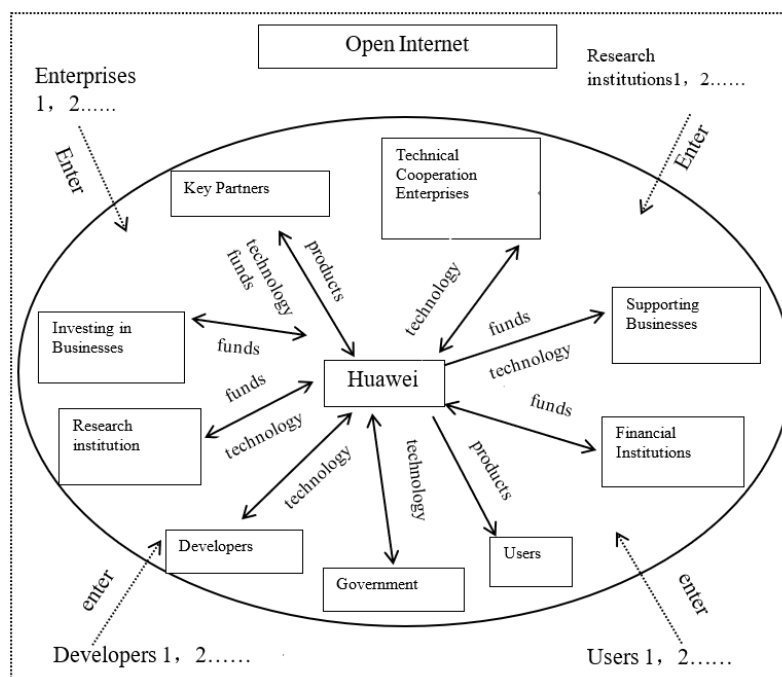


Figure 2. Actor-Network of Huawei’s Innovation Ecosystem

In the entire Actor Network, Huawei, as the core actor, actively proposes initiatives, integrates resources, reduces barriers and risks for other actors to enter the Actor Network, and increases the

Actor Network's appeal to additional actors. Moreover, key partners including China Mobile, China Unicom, China Telecom, and the China Academy of Information and Communications Technology have maintained close collaboration with Huawei in recent years in terms of technology, products, as well as funding, engaging in innovative activities to empower enterprise innovation performance. Certain small and medium-sized enterprises (SMEs) operating in the realm of 5G innovation encounter obstacles including financing constraints and a dearth of knowledge resources. Huawei actively supports these entities through the provision of financial and technical assistance, facilitation of stable strategy formulation, and implementation of digital transformation. For Huawei's investment, financial, and technical cooperation partners, Huawei conducts financial and technical exchanges tailored to their respective needs, enabling these enterprises to gain competitive advantages and strengthen innovation cooperation for mutual success. Research institutions like the China Institute of Information Technology Standards, through financial and technical exchanges, provide Huawei with technological innovation and high-tech talents. Developers entice Huawei to participate in technological breakthrough collaborations by capitalizing on their technological advantages, while involvement in other domains is comparatively limited. Government decisions, including signing comprehensive and deepening strategic cooperation agreements with Huawei, enable active engagement in technological exchanges, thereby advancing the establishment of research institutes, computing industries, and artificial intelligence industries, and expediting digital development within the province. Huawei, through the application of technologies including big data and cloud computing, innovates in the product domain, providing users with innovative insights into market commodities, meeting user demands, and realizing knowledge value. Huawei combines its interests with those of other actors, allowing each actor to fully leverage its role in the actor-network, thus forming a stable and healthy Actor Network.

The actor-network of Huawei's 5G innovation ecosystem remains consistently open. Leveraging its influence and continuous technological breakthroughs, Huawei actively expands new partnerships while maintaining existing ones. This ongoing effort attracts a continuous influx of new enterprises and research institutions into the actor-network. Simultaneously, other actors within the network actively leverage their influence to assist Huawei in identifying exceptional collaborators. For instance, companies including Ericsson and Nokia, known for maintaining high technological standards in the field of communication technology, contribute to expanding external collaborations for Huawei through sustained cooperation. Companies including OPPO, which entered the technological landscape later, achieved breakthroughs through collaboration with Huawei, paving new paths for 5G development for numerous enterprises. Key partners of Huawei, including Mobile and Unicom, see their influence grow in their respective domains, providing robust support for the development of the actor network. Consequently, as actors in the network continuously update and optimize, leading to a stabilization in their numbers, the actor-network gradually expands in scale and flows smoothly.

6. Conclusion

This paper explores the innovation ecosystem of Huawei's 5G technology. Grounded in actor-network theory, the text provides a precise delineation of the diverse entities comprising the innovation ecosystem and evaluates the challenges and requirements faced by these entities in relation to 5G technology. Moreover, the goal is to depict the construction process and network status of Huawei's 5G Technology Innovation Ecosystem through four translation stages. The paper aims to elucidate how Huawei addresses the collaborative innovation challenges faced by various actors within the innovation ecosystem, ultimately attracting more high-quality actors to participate in the ecosystem.

Research findings indicate that (1) heterogeneity plays a crucial role in studying the process of Enterprise Innovation Ecosystem within actor-network-theory. In actor-network theory, human actors and nonhuman actors are equally substantial and cannot be arbitrarily substituted. Within the Huawei

5G Technology Innovation Ecosystem, human actors primarily include enterprises, research institutions, financial organizations, developers, government entities, and users. Nonhuman actors mainly encompass funding, technology, and commodities. Both human and nonhuman actors actively participate in the innovation activities of enterprises, contributing to the stable operation of the actor-network.

(2) The translation of the four stages, “problematization”, “interessement”, “enrollment”, and “mobilization”, provides a clear depiction of the Actor-network construction process. As a core actor within the network, Huawei, in the “problematization” stage, accurately identifies the issues of other actors, establishes different solutions for each actor, and defines compulsory passage points to achieve common goals. Furthermore, in the “interessement” stage, Huawei sets common goals and forms alliances with other actors based on the compulsory passage points, enabling efficient innovation activities directed towards specific objectives. During the “enrollment” stage, Huawei, leveraging its leading industry position and innovative technologies, continuously attracts other actors to join the actor-network, thereby expanding its scale. In the “mobilization” stage, Huawei efficiently organizes all actors within the network, providing ample opportunities for resource exchange and strengthening collaborative innovation activities among enterprises to collectively advance the development of 5G technology. Through these four stages, Huawei successfully constructs a robust actor-network.

(3) The actor-network of the Huawei 5G Technology Innovation Ecosystem is characterized by continuous openness and stable operation. In recent years, Huawei, leveraging its influence and continuous technological breakthroughs, has consistently attracted new enterprises and research institutions to join the actor-network. Huawei's key partners, with their solid positions in this actor-network, actively contribute to the ecosystem and aid Huawei in identifying outstanding collaborators. Consequently, as actors within the network continuously update and optimize, and as the system operates at its optimum efficiency, the total number of actors in the network tends to stabilize, and the network scale becomes more consistent.

(4) Facilitating industry digital transformation is a significant driver for other actors to join the actor-network of the Huawei 5G Technology Innovation Ecosystem. Through the analysis of 55 compiled reports, it is evident that a substantial proportion of actors join the actor-network of the Huawei 5G Technology Innovation Ecosystem with the primary motive of advancing industry digital transformation, which is attributed to the current central position of digital platforms in the global economy. The advancement of 5G technology empowers organizations to drive the digital transformation of their respective sectors, thereby facilitating their integration into the global innovation ecosystem.

Based on actor-network theory, this research examines the technological innovation process employed by Huawei in the context of 5G technology. According to the research findings, Huawei boasts an extensive network of actors and a multitude of partners, which collectively form a benign innovation ecosystem that drives ongoing advancements in the realm of 5G technology. Moreover, it functions as a significant point of reference for Huawei's research and development advancements in various technological sectors, amassing and supplying an ample supply of superior Actor network resources and a structured environment.

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