Innovation Mechanisms for 5G-Based Library Services (Postprint)

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Abstract

This article introduces the latest developments in 5G, and based on the technical characteristics of 5G and the current state of industry applications, analyzes three categories of innovative services in libraries: video-based service innovation, data-based service innovation, and artificial intelligence-based service innovation, and summarizes the development trends of service innovation for 5G in libraries.

Full Text

Research on 5G-Based Library Service Innovation Mechanisms

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Abstract

This paper introduces the latest developments in 5G technology and analyzes three categories of innovative library services based on 5G's technical characteristics and current industry applications: video-based service innovation, data-based service innovation, and artificial intelligence-based service innovation. The paper also summarizes the development trends of 5G-enabled library service innovation.

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5G is the abbreviation for 5th Generation Mobile Networks, where "G" stands for Generation—the fifth generation of mobile communication technology. The ITU Radiocommunication Sector (ITU-R) has officially designated 5G as "IMT-2020," where IMT stands for International Mobile Telecommunications System and "2020" indicates commercial implementation in 2020. As a technology that connects everything, 5G employs an entirely new network architecture with ultra-high transmission speeds comparable to fiber optics, millisecond-level ultra-low latency, and the capacity for hundreds of billions of connections, ushering in a new era of ubiquitous intelligent connectivity.

1. Overview of 5G Development

1.1 5G Standardization Progress

In 2015, the International Telecommunication Union (ITU) officially released the 5G vision and requirements, identifying three major service scenarios: Enhanced Mobile Broadband (eMBB), Ultra-Reliable Low-Latency Communication (URLLC), and massive Machine-Type Communication (mMTC). In 2016, 3GPP established the 5G protocol roadmap. The first-phase 5G standard, Release 15, focused on enhanced mobile broadband capabilities (the eMBB scenario) to meet explosively growing traffic demands and was frozen in June 2018. Release 16, the second phase, primarily enhanced URLLC standards to establish a foundation for high-reliability, low-latency data transmission networks, thereby supporting the mMTC scenario, and was frozen in July 2020. Currently, standardization work on Release 17 is still underway, which will further enhance network and service capabilities, with a planned freeze date of June 2022 [1]. From R15 to R17, 5G standards continue to be updated and improved, transforming 5G networks from merely "functional" to "user-friendly," evolving from pilot demonstrations to large-scale deployment.

1.2 Global 5G Development Overview

As of October 2020, 124 operators in 49 countries had deployed over 930,000 5G base stations, with more than 118 commercial 5G networks launched worldwide. Global 5G users reached 124 million, and 303 commercial 5G terminals were available, with an increasing variety of terminal types such as drones emerging [2]. 5G-based business formats have begun to take shape, with several countries initiating 5G-centric industrial layouts. For instance, the South Korean government has advanced its new "XR+α" project, the EU launched the "Horizon 2020" research program, Japan introduced the "Beyond 5G" promotion strategy outline, and the U.S. Center for Strategic and International Studies released the "Accelerating 5G in America" report [3]. China has introduced initiatives such as "New Infrastructure" and the "512 Project," leveraging 5G to empower industrial internet. Currently, over 1,100 5G+ industrial internet projects have been

implemented, with more than 32,000 5G base stations deployed in industrial internet scenarios [4].

1.3 Library-Related Research on 5G

Although 5G industry convergence applications remain in the early stages of development, research on 5G as a breakthrough and innovative technology entered the library field long ago. In 2015, Chu Jiewang et al. discussed how 5G promotes innovation in mobile information service methods, service models, and service systems [5]. Cheng Bing et al. examined the characteristics of library mobile information services in a 5G environment: rich media service resources, intelligent service methods, contextualized virtual perception, smart service models, and ubiquitous service venues [6]. Li Gewe analyzed library development strategies for the 5G era: exploring 5G application scenarios in libraries, migrating library services to cloud platforms, enhancing immersive experiences and smart services, and improving library data management [7]. Liu Wei et al. proposed ten application scenarios for 5G in libraries: seamless borrowing, navigation and guidance, ultra-high-definition panoramic interactive live streaming, smart study rooms, smart venues, cloud classrooms, precise recommendation, robot services, intelligent security, and regional alliance service coordination [8].

1.4 5G-Driven Service Innovation in Libraries

Employing entirely new communication technologies and standards, 5G compensates for 4G network limitations with its rich technical characteristics, creating favorable conditions for mobile information service innovation. Based on 5G's development trajectory, technical features, and application status, we can predict that 5G will profoundly impact library service content and methods in areas such as video, data, and artificial intelligence.

2. Three Types of Innovative Services

2.1 Video-Based Service Innovation

Video-based information and ultra-high-definition video represent development trends in the 5G information industry. Video has become an important means for leisure, entertainment, learning, and communication, transforming people's information behaviors and becoming a crucial way of understanding the world. With the support of 5G networks, video clarity and smoothness have further improved, stimulating greater demand for video consumption. According to the "5G Entertainment Economy Report" released by Ovum, a world-renowned telecommunications industry consulting firm, 5G users' average monthly data traffic will increase sevenfold over the next decade, with 90% consumed by video [9]. Video is no longer merely a carrier but serves a linguistic function equivalent to text and images, potentially becoming a new language paradigm in the 5G era [10]. Most videos watched by people fall into three categories: short

videos meeting fragmented time needs, ultra-high-definition videos providing visual experiences, and live streams enabling real-time interaction. Libraries can develop innovative services based on these three video types.

2.1.1 Short Video-Based Knowledge Services Short videos, characterized by their brevity, knowledge content, and entertainment value, cater to the needs of fast-paced modern life. According to the 47th "Statistical Report on China's Internet Development," as of December 2020, short video users reached 873 million, accounting for 88.3% of all internet users [11]. Short videos have become an important information dissemination channel, making complex knowledge accessible through vivid audio-visual content that can be shared and commented on, facilitating dissemination and interaction. Many libraries' public platforms have evolved from "two microblogs and one terminal" to "two microblogs, one terminal, and one TikTok," where "one TikTok" refers to the Douyin short video platform. Currently, most short videos are individually produced with uneven quality and an overall entertainment orientation. In August 2018, the Cyberspace Administration of China proposed: "Encourage traditional mainstream media, government agencies, public institutions, enterprises, people's organizations, and social organizations to establish accounts on major online short video platforms to expand online dissemination effects" [12]. As public institutions and professional knowledge organizations, libraries' participation in short video production would significantly improve overall video quality.

2.1.2 High-Definition Video-Based Resource Development From 4G to 5G, ultra-high-definition video has gradually entered public life, opening new visual worlds through its detailed imagery. 5G's high bandwidth and low latency provide strong support for online ultra-high-definition video playback. As 5G continues to improve and upgrade, more ultra-high-definition videos will emerge. While libraries' electronic resources include video materials, their proportion remains relatively low—a situation likely to change in the future. On one hand, high-quality video resources will become increasingly abundant; on the other hand, user demand for video resources will grow. Video resources, particularly ultra-high-definition videos, will become a direction for resource development.

2.1.3 Live Streaming-Based Consultation and Training Services "5G + Live Streaming" represents the fastest-implemented 5G application. Live streaming enables real-time video communication with strong immersive and interactive experiences based on fan interaction models. Some popular influencers have tens of millions of followers, wielding greater influence than some traditional media. During the COVID-19 pandemic, frequent online meetings and learning cultivated users' habits of video communication and increased acceptance of live streaming. Libraries can experiment with live streaming as a means of interacting with readers and sharing knowledge. Video consultation services can provide assistance to readers outside the library, while live stream-

ing library events can attract greater participation. Additionally, libraries can conduct synchronized live broadcasts of lectures with panoramic playback using 5G technology, enabling broader audiences to participate.

2.2 Data-Based Innovative Services

In the 5G environment, the Internet of Everything will generate geometrically growing data. Not only humans but also intelligent terminals produce data, all of which flows into the internet's data torrent, surging from one terminal to another. Faced with this massive data environment, libraries need to enhance their data processing capabilities and leverage data value.

Libraries have long faced difficulties in collecting and organizing reader data. On one hand, large reader populations generate fragmented data; on the other hand, each reader's information behavior varies significantly, making continuous tracking and recording challenging. In the 5G environment, AI and IoT can largely solve this problem. First, intelligent sensing devices can collect readers' offline visit data—for example, when a reader enters a reading room, access control sensors detect and identify the entry, creating browsing records similar to online activity. Through autonomous communication between devices, libraries can record readers' access trajectories and form relatively complete data chains. Moreover, 5G smart devices possess certain data processing capabilities, enabling preliminary data processing and improving library data processing efficiency. Data collection and processing by intelligent devices will provide strong support for libraries' big data construction.

2.3 AI-Based Innovative Services

With the implementation of 5G, the expansion of IoT, the popularization of intelligent terminals, and the application of robotics, libraries' intelligence levels will continuously improve. Currently, libraries have achieved self-service borrowing and returning, automatic inventory, and other functions using RFID technology, but the intelligence level remains insufficient, primarily due to RFID's relatively weak communication capabilities. Under the Internet of Everything, intelligent devices can perceive their surroundings, respond autonomously, and possess autonomous communication and data processing capabilities, significantly enhancing their intelligence levels.

AI can improve libraries' automation levels, further simplify business processes, and enhance overall operational efficiency. After achieving highly intelligent book management, readers only need to submit a request to borrow books—book location, retrieval, borrowing, and other processes can be completed by intelligent devices. Upon receiving a reader's request, the system first searches for and locates books through intelligent terminals and smart shelves, then uses intelligent book carts to retrieve them, delivers them to pickup lockers, and sends pickup notifications to readers, who simply collect the books from the lockers. This greatly simplifies the borrowing process, saving readers' time

while increasing book circulation rates.

3. Trends in Library Service Innovation Under 5G

3.1 Reshaping Value: Connectivity and Convergence

An industry saying suggests that "4G changes life, 5G changes society." As a technology connecting everything, 5G possesses the power to drive social development. Former Minister of Industry and Information Technology Miao Wei noted that 5G will be used 20% for human-to-human communication and 80% for machine-to-machine communication. The future internet will feature multi-subject, multi-level interconnectivity among people, machines, and people-to-machines. Therefore, the 5G world will be one of ubiquitous connectivity. Libraries need to leverage 5G to form service radiation, establishing more connections with other industries for resource sharing and complementary advantages in terms of service breadth. In terms of service depth, libraries should use intelligent devices to provide instant services and service tracking for readers anytime, anywhere, continuously improving service quality. Only through cross-boundary integration and multi-dimensional connectivity can libraries further stimulate innovation potential and maximize their value.

3.2 Role Transformation: From Collector to Promoter

5G dramatically changes users' information behaviors. The popularity of short videos and live streaming leads more people to prefer video-based information acquisition, while libraries' collections of books, magazines, and other resources remain primarily text-based. This shift in user information preferences poses significant challenges to libraries. Libraries need to leverage their resource advantages and utilize 5G technology to diversify knowledge promotion methods. Professional knowledge becomes more accessible and acceptable to the public when presented through images, videos, or dynamic demonstrations using VR/AR technologies. Traditionally, libraries have focused on collection functions, but in the new era, libraries must transform their role positioning—not only collecting knowledge but also disseminating it, becoming content producers and facilitating knowledge circulation.

3.3 Ubiquitous Service: The Ever-Present Library

Using 5G-enabled intelligent sensing devices to create new service access points, library services will become everywhere and always available. By establishing data-driven libraries and utilizing big data analytics to identify readers' potential needs, services can anticipate demands. After readers submit requests, services can be delivered directly and rapidly. Even without explicit requests, intelligent recommendations can be made based on big data analytics. Therefore, once various technologies mature, operations for readers will become extremely simple—or even unnecessary. Services like borrowing and locating books will

require only a simple request from readers. Through this ease of use, libraries will become ubiquitous presences.

5G reveals various possibilities for library innovation. As 5G continues to advance, its applications will become increasingly widespread. How to implement 5G in libraries, integrate it into library business processes, and enrich library service ecosystems are questions that both libraries and the industry must consider. Libraries need to maintain an open mindset, recognize the driving force of mobile communication technology on social development, and foresee the future through 5G. Currently, 6G is already under development, and the continuous iterative upgrading of mobile communication technology has become the new normal. Therefore, even if libraries miss the 5G "express train," there will be 6G and even 7G ahead. In an era of rapidly evolving communication technology, library service innovation will remain an ongoing journey.

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Note: Figure translations are in progress. See original paper for figures.