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Exploration and Practice of Free Campus Network in Institutions of Higher Education: A Case Study of Dalian Jiaotong University

Guoli Zhang*, Hang Su, Gang Li

Dalian Jiaotong University, Dalian 116028, Liaoning, China

**Author to whom correspondence should be addressed.*

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Abstract: Against the backdrop of digital education, the campus network has become an indispensable infrastructure in universities, yet the limitations of traditional operation models have become increasingly prominent. This paper systematically presents the entire process of the free campus network reform initiated by Dalian Jiaotong University, focusing on its background, implementation paths, existing challenges, and optimization strategies. It explores the construction of an on-demand service system for campus networks, and practical experience can provide some reference and guidance for sister universities.

Keywords: Digital education; Campus network; Free model; Construction; Optimization

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1. Introduction

At the current stage of comprehensive promotion of digital education, campus networks have become the core infrastructure supporting teaching, scientific research, management work, and daily activities of teachers and students in universities. With the continuous acceleration of smart campus construction, the demands of teachers and students for network bandwidth, coverage, and service quality are increasing. Traditional campus network operation models such as “pay-per-traffic” and “package-based charging” have gradually revealed limitations—they not only increase the financial burden on teachers and students, but also to some extent restrict the transmission of data, the sharing of online teaching resources, and the application and popularization of campus digital services. To address this bottleneck, Dalian Jiaotong University initiated a reform to make campus internet free of charge in the first half of 2023. Aiming to build a “free, high-speed, stable, and secure” campus network service system through resource integration, technological optimization, and mechanism innovation, the reform provides high-quality digital support for teachers and students and facilitates the university’s “Double First-Class” construction and high-quality development.

2. Background analysis of the free campus network

2.1. The inevitable path of educational transformation

In recent years, the Ministry of Education has successively issued documents such as the *Education Informatization 2.0 Action Plan* [1], the *Opinions on Strengthening the Informatization of Education Management in the New Era* [2], and the *Notice on Improving the Network Management and Service Quality of Institutions of Higher Education* [3], clearly proposing to "promote the interconnection, integration, and openness of resource public service platforms and management public service platforms, and build a large 'Internet plus Education' platform" and "enhance campus network service capabilities to meet the diverse online needs of teachers and students." As a basic service for teachers and students, the free campus network is a key means to promote educational equity, reduce the cost of internet access, and facilitate inclusive access to educational resources, which is the development direction of educational and teaching informatization.

2.2. Meeting the teaching, research, and living needs of teachers and students

Before the free reform, Dalian Jiaotong University adopted the "basic package + excess charging" model, which had three major pain points. Firstly, when research teams transmit large-scale experimental data and literature, high traffic fees increase research costs. Secondly, the popularization of online resource public service platforms (such as XuetangX, Yuketang, and XueXiTong) and various virtual simulation online experiment platforms has led to a sharp increase in students' daily use of Internet traffic, resulting in a corresponding increase in economic burden. Thirdly, on-campus daily service scenarios (such as campus one-card system, self-service equipment in living areas, logistics services, etc.) are highly dependent on the campus network. The growing call for a free campus network from teachers and students has become a direct driving force for the reform.

2.3. Campus network is the core support for the construction of a smart campus

The university is promoting the construction of "Smart Jiaotong University," covering four major areas: smart teaching, smart scientific research, smart management, and smart services. For example, the Rail Transit Virtual Simulation Experiment Center requires high-speed networks to support concurrent access from multiple terminals; the smart academic affairs system needs stable networks to ensure high-frequency operations such as course selection and score inquiry; and IoT devices such as campus one-card systems and security monitoring require seamless network coverage. Problems such as uneven network resource allocation and poor user experience under the traditional charging model have become a "shortcoming" in the construction of smart campuses, making the free campus network an inevitable trend.

3. Implementation path of the free campus network

3.1. The only way for the transformation of digital education

Before launching free network services, it is necessary to first solve basic guarantee issues to "know oneself and others" and avoid the situation of "free access leading to network outages."

3.1.1. Network capacity assessment

Through data analysis [4] (such as average concurrent users, peak concurrent users, bandwidth utilization rate, network resource capacity, security redundancy, etc.), it is judged whether existing network equipment (switches, servers, exit bandwidth) can support the traffic growth after full free access. If insufficient, an upgrade plan is formulated.

3.1.2. Cost calculation and fund reserve

Calculate the annual costs after free access, including bandwidth rental, equipment maintenance, and personnel salaries. Coordinate financial appropriations in advance or expand cooperative funds to ensure stable investment for at least 1–2 years.

3.1.3. User demand survey

Collect and organize the actual needs of teachers and students for campus networks, such as bandwidth speed, coverage range, and stability, through online surveys or on-site user interviews, in order to avoid complaints and online public opinion caused by substandard services after the campus network is free.

3.2. Free network performance guarantee

Performance guarantee is the biggest challenge faced by the free campus network. The university increases network bandwidth, optimizes network equipment through self-raised funds, and optimizes the network architecture through technical means to ensure "free access without quality degradation."

3.2.1. Constructing a three-tier "core-aggregation-access" network architecture

A network security architecture based on the zero-trust concept is constructed to effectively address challenges such as blurred network boundaries, security risks of mobile terminals, and refined management of network permissions [5].

Core layer: Upgrade the core access switch to a dual-core 10 Gigabit interconnect switch, and achieve bandwidth overlay and redundancy through port aggregation. Adopting virtualization technology (VSU) to achieve unified management and link backup. By increasing the bandwidth capacity to three times its original capacity, it can meet the concurrent access needs of over 20,000 users.

Aggregation layer: As an intermediary between the access layer and the core layer, deploy aggregation switches in pre-divided network areas, set up security policies, network routing, and other settings to reduce the load on core layer devices and minimize data transmission latency.

Access layer: In living areas, study areas, laboratories, and other areas, a "wired + wireless" dual access mode is used to provide workstation access for the local network segment. Adopting a multi-AP collaborative networking mode to build a wireless network, achieving seamless roaming and load balancing, effectively solves the problem of network lag in high-density wireless internet scenarios.

3.2.2. Deploying an intelligent traffic management system

Based on user identity (teachers/students/visitors) and business demand characteristics, bandwidth resource distribution is dynamically adjusted according to preset rules by continuously monitoring network load status [6]. Priority is given to guaranteeing bandwidth for teachers' scientific research and teaching platform access (up to 300 Mbps), and the default bandwidth for students' daily Internet use is 100 Mbps. By using a tiered speed limit for traffic, when a certain amount of traffic is used in the current month, the network speed will automatically drop to 30 Mbps.

"Elastic speed limiting" is implemented for non-academic traffic such as P2P downloading and large-scale games. During peak network hours (e.g., 8 p.m. to 11 p.m.), the proportion of such traffic is automatically limited to avoid occupying academic bandwidth.

3.2.3. Building a local resource caching platform

Common educational resources (such as China University MOOC, Chaoxing Learning Tong, CNKI, Wanfang Database, etc.), operating system images, and software installation packages are cached on local campus servers. Teachers and students can access these resources without consuming external network traffic, which not only reduces the pressure on external network bandwidth but also improves access speed.

3.3. Construction of a sustainable network service system

Free access does not mean "letting it go." Schools provide solid guarantees for the long-term stable operation of campus networks by improving institutional design, clarifying responsibility allocation, building a strong network security defense line, and continuously improving service quality.

3.3.1. Establishing a "multi-department collaboration" management mechanism

A "Leading Group for Free Campus Network Work" led by the president is established, with members including the Information Technology and Data Management Center, Academic Affairs Office, Science and Technology Office, Finance Office, Logistics Group, and other departments.

The Information Technology and Data Management Center is responsible for technical operation and maintenance (such as equipment inspection and troubleshooting); the Academic Affairs Office and Science and Technology Office connect with the network needs of teaching and scientific research respectively; the Logistics Group is responsible for guarantees such as computer room power supply and equipment heat dissipation, forming a working pattern of "each performing its duties and collaborative linkage."

3.3.2. Improving the network security guarantee mechanism

Implementing "real-name authentication": Teachers and students need to access the campus network through unified identity authentication (student ID/staff ID + password), and visitors need to register their identity information and be guaranteed by on-campus personnel to effectively prevent illegal user access.

Formulate the Measures for the Management of Campus Network Use at Dalian Jiaotong University to regulate the network use behavior of teachers and students, clearly prohibit using the campus network for illegal activities (such as spreading harmful information and conducting network attacks), and take measures such as suspending network access and circulating criticisms against violating users to strengthen network security awareness.

3.3.3. Optimizing the user service mechanism

Establish a closed-loop service channel of "online repair + offline response": Online, fault repair and consultation services are provided through the WeChat official account of the Information Management Center, with a response time of no more than 1 hour; offline, "grid network service stations" are established in each campus, with operation and maintenance personnel assigned to each grid area, responsible for daily inspections, equipment maintenance, on-site debugging, and user communication and consulting services.

Regularly carry out network use training and network service satisfaction surveys: Network use training is conducted through freshmen orientation and new faculty induction training to effectively reduce failures caused by improper operation and thus reduce operation and maintenance pressure; targeted network services are carried out based on the survey feedback from teachers and students.

4. Challenges and optimization strategies after the free campus network

Although a free campus network is a development trend, it still faces three core challenges in practice: financial pressure, bandwidth abuse, and security risks, which need to be addressed through "diversified fundraising, refined management, and technical protection."

4.1. Financial pressure and cost sustainability remain core challenges

After the campus network becomes free, an additional annual expenditure of 500,000 to 2 million yuan is required (including bandwidth service fees, equipment update costs, and operation and maintenance personnel salaries), which is difficult for local universities with limited financial budgets to bear for a long time. It is necessary to alleviate financial pressure by striving for special construction funds, cooperating with telecom operators, and reducing expenses through internal potential tapping.

4.2. Bandwidth abuse and resource waste are still urgent issues to be solved

After the campus network becomes free, some teachers and students use the network excessively (such as downloading a large number of non-academic videos and keeping P2P software running for a long time), leading to reduced network speed in teaching areas, laboratories, and living areas during peak hours. It is necessary to alleviate network pressure by dynamically limiting the "peak bandwidth per user" through SDN technology, guiding users to use the network reasonably, and publishing the "Top 10 users of bandwidth usage in each area" monthly.

4.3. The potential risks of network security and data privacy cannot be ignored

After the implementation of the free policy on the campus network, the user base has significantly expanded compared to before, and the risk of violations such as "account lending," "account theft," "accessing foreign malicious websites through the campus network," and "participating in online brushing" has increased. At the same time, the unified authentication system may involve the private data of teachers and students (such as Internet access records), bringing challenges to network security management. It is necessary to strengthen security protection by deploying "firewall + Intrusion Detection System (IDS) + Intrusion Prevention System (IPS)" to block malicious IPs, filter harmful websites, and automatically lock "abnormal logins" (such as simultaneous login of the same account in multiple locations). For privacy protection: strictly comply with the Cybersecurity Law and the Personal Information Protection Law, adopt technical measures to monitor and record network operation status and network security incidents, and retain relevant network logs for no less than six months in accordance with regulations [7] to maximize the protection of private data; popularize knowledge such as "account password protection" and "not accessing illegal websites" through freshmen orientation and campus security lectures, strengthen network security education, and improve the network security awareness of teachers and students.

5. Retrospect and prospects

The exploration of a free campus network at Dalian Jiaotong University is a vivid practice of universities oriented to the needs of teachers and students and promoting the transformation of digital education. Through the path of "resource integration, technological optimization, and mechanism innovation," the university has not only solved the problem of "balancing free access and performance" but also accelerated the construction of a smart campus with the campus network as a link, providing strong support for the improvement of educational

and teaching quality and the development of scientific research innovation. In the future, with the iteration of technology and the improvement of models, a free campus network will become a "standard configuration" for the digital construction of universities, and the practical experience of Dalian Jiaotong University will provide a reference for more universities that is worthy of learning and replication.

Disclosure statement

The authors declare no conflict of interest.

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