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Research on the Construction of "Module-as-a-Service" Computer Network Courses

Zhou Ming[a], Zeng Guangjun[b], Chen Kebin[c], Tan Yuan[d], Liang Jing[e]

Information Support Force Engineering University, Wuhan, China
[a]zmxc2001@sohu.com, [b]guangjun_zeng@sohu.com, [c]chenkebin17@nudt.edu.cn, [d]tanyuan17@@nudt.edu.cn, [e]1628328@qq.com

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Abstract: In the context of the digital transformation of higher education and the construction of new engineering disciplines, computer network courses are facing a series of practical challenges such as lagging update of teaching content, difficulty in precise adaptation of teaching, and low efficiency in resource utilization due to rapid technological iteration, increasingly diverse learning situations, inefficient resource integration and insufficient ecological synergy. To systematically address these challenges, this paper innovatively introduces the concept of "module as a service", aiming to construct a new model of curriculum construction based on standardized, reusable, and flexibly schedulable knowledge modules and characterized by intelligent and precise service delivery. The research shows that the "module as a service" model can effectively promote the transformation of the curriculum form from a static, closed, unified paradigm to a dynamic, open, personalized paradigm, not only providing teachers with an operational curriculum reform path, but also offering theoretical references and practical paradigms for the digital reshaping of similar engineering courses.

1. Introduction

In the context of the digital economy becoming the core engine of global development, innovation in information technology, especially in computer network technology, is advancing at an unprecedented speed. The integrated application of technologies such as cloud computing, Internet of Things, artificial intelligence, 5G/6G continues to reshape the social production structure and the demand for talent capabilities[1][2]. As a key course for cultivating high-quality talents in the field of information technology, the quality of computer network teaching is directly related to the core competitiveness of students majoring in related fields.

However, the current construction and teaching practice of computer network courses in colleges and universities are trapped in multiple predicaments. On the one hand, the rapid shortening of the technological iteration cycle and the deepening of interdisciplinary integration have led to blurred boundaries of the curriculum knowledge system, explosive growth of content, and a heavy burden for teachers to track the frontiers and integrate knowledge. On the other hand, the student body is increasingly diverse in terms of professional background, prerequisite foundation, career orientation

and learning preferences, making it difficult for "standardized" teaching plans to maximize "personalized" learning outcomes. In addition, although digital teaching resources are considerable in quantity, their combined effectiveness is far from being fully realized due to the lack of an effective organizational model and an intelligent supply mechanism. These factors have collectively led to a significant gap between teaching input and output benefits, increased teacher fatigue, and limited students' learning experience and depth.

In response to these challenges, this paper proposes to systematically integrate the concept of Module as a Service (MaaS) into the construction of computer network courses. The idea draws on the core idea of "service-oriented" in software architecture, aiming to construct a new curriculum system that is responsive, adaptable, and ecologically sustainable by deconstructing the curriculum content into cohesive, reusable standardized modules and achieving their flexible combination, intelligent recommendation, and precise delivery through service-oriented interfaces. Based on this, the study aims to achieve the following three goals: First, clarify the theoretical connotation and practical orientation of the "module as a service" model in the field of education, especially in the construction of engineering education courses; Secondly, deeply diagnose the core pain points in the teaching of current computer network courses; Ultimately, design a logically consistent and highly operational "module as a service" curriculum construction strategy framework, with the aim of providing practical reform paths for college teachers and promoting the essential transformation of curriculum teaching from "resource accumulation" to "intelligent service".

2. Conceptual Framework

Before presenting specific questions and strategies, it is necessary to construct the core conceptual framework of this article. This framework aims to define the educational connotation of "module as a service" and clarify the disciplinary characteristics that are highly compatible with computer network courses, thereby laying a theoretical foundation for subsequent analysis.

2.1. The Educational Connotation of "Module as a Service"

The conceptual paradigm of "Module as a Service" is rooted in modular design ideas and service-oriented architecture (SOA) concepts in the field of computer science. Modularization emphasizes the decomposition of complex systems through highly cohesive, low-coupled components to enhance their maintainability, reusability, and scalability. SOA further encapsulates functional units as independent, network-callable services, achieving loose coupling and agile delivery of the system[3].

The transfer of this technical paradigm to the field of education is profoundly appropriate. As educational informatization enters an era characterized by "connectivity" and "intelligence", the organization of educational resources and services is in urgent need of innovation. "Module as a service" goes beyond the traditional form of resources based on static courseware packages or entire online courses (MOOCs), advocating for a more refined, flexible, and intelligent granularity. Its core educational content includes:

1) Service-oriented encapsulation of knowledge: encapsulating discrete knowledge points and skill points into independent "learning microservices" that carry teaching objectives. Each service has a complete "goal-content-activity-assessment" teaching loop.

2) On-demand supply model: Teaching services are no longer one-way, fixed push, but are dynamically combined and called on demand based on specific teaching scenarios and the real-time status of learners, transforming from "people seeking resources" to "services seeking people".

3) Openness of the ecosystem: Through standardized interfaces, high-quality modular services from different sources and different periods can be conveniently integrated, reorganized and

evolved to form an open education ecosystem contributed and consumed by multiple subjects such as teachers and students.

This model is highly consistent with modern educational concepts such as "open educational resources", "personalized learning paths", and "competency-based education", providing a new methodology for solving problems such as rigid curriculum content and insufficient adaptation of teaching.

2.2. Computer Network Courses

Computer networks are a hub in the information technology discipline system. Its inherent nature determines that it has a particularly strong demand for the "module as a service" model, mainly in the following four aspects:

1) Dynamic evolution: Network protocols, devices, architectures, and application scenarios are constantly evolving rapidly, requiring course content to have the "loose-leaf" quality of being able to insert new modules and replace old ones at low cost.

2) Multi-level practicality: The course covers the entire stack from low-level signal transmission to top-level application protocols, with theoretical abstraction closely integrated with engineering practice. The module needs to be able to flexibly support experimental services of different granularities and environments, from protocol analysis simulation to real network configuration debugging.

3) Cross-disciplinary differences: The demand graphs for network knowledge vary significantly among different disciplines such as computer Science and technology, Network engineering, Information Security, Internet of Things Engineering, etc. The courses are required to be like building blocks, quickly assembling customized collections of knowledge modules according to the training programs of different disciplines.

4) Strong engineering and social attributes: Involving network planning, management, security, etc., it requires a large number of cases, projects and contextualized teaching resources, which are naturally suitable for management and contextualized allocation in the form of modular services.

Therefore, the "module as a service" transformation of computer network courses is not only a technical adjustment to address teaching challenges, but also a strategic choice to follow the discipline's development laws and achieve the goal of talent cultivation[6].

3. Analysis of Teaching Problems in Computer Network Courses

The current teaching model of computer network courses is facing a series of structural challenges when responding to the dynamic technological environment and diverse learning demands. This section aims to systematically analyze the core problems existing in the teaching practice of the computer network course, precisely identify the pain points of the current course, and establish a clear problem-oriented approach for the proposal of subsequent construction strategies.

3.1. The Dilemma of Dynamic Integration and Agile Updates of the Curriculum Knowledge System

At present, network technology is developing rapidly, IPv6 is fully deployed, SDN/NFV is becoming increasingly mature, and the cross-domain integration of "network +" is accelerating, which continuously expands the knowledge boundaries of the curriculum and rapidly iterates the core content. Teachers are confronted with the impact of the "flood of knowledge", and within the limited class hours, they have to ensure the depth of classic theories while taking into account the

breadth of cutting-edge technologies, making a difficult choice. Traditional textbooks have a long update cycle, and teachers often have to devote a lot of energy to sifting, digesting, translating and integrating from academic papers, technical documents and industry reports into teaching materials. This process is not only burdening but also, due to the limitations of personal vision and energy, can easily lead to one-sided or lagging course content in practical application. The simultaneous update of the experimental environment is even more costly, leaving many practical teaching sessions stuck on relatively outdated technology stacks.

3.2. The Challenge of Precision Instructional Design under Heterogeneous Learning Conditions

The composition of students in current computer network classrooms in colleges and universities is becoming increasingly complex. The same class may include students from different professional directions, with different prerequisite knowledge bases such as programming skills and hardware cognition, and with different career interests such as research and development, operation and maintenance, and security. Uniform curriculum standards, teaching schedules, and assessment methods are difficult to meet the effective learning needs of all students. Students with a weak foundation may lose confidence because they can't keep up with the pace, while those with extra capacity may lose motivation because they feel "hungry". Teachers often sacrifice depth and personalization in a compromise that takes the big picture into account when designing teaching, making it difficult to achieve the best results of teaching students according to their aptitude.

3.3. The Phenomenon of Insufficient Comprehensive Effectiveness of Teaching Resources

To assist teaching, a wide variety and large quantity of resources have been built at all levels, including national and provincial-level excellent courses, school-level resource libraries, and individual teacher accumulations. However, these resources are often in an "isolated" state, characterized by inconsistent formats, scattered storage, and unclear labeling. Teachers often have to search, download, convert and edit resources across multiple platforms in preparation for a single lesson, a cumbersome and inefficient process. Students are also prone to choice difficulties and cognitive overload when faced with a vast and unorganized array of recommended resources. The "abundance" of resources does not directly translate into "excellence" in teaching. Instead, due to the high costs of screening, matching and integrating, the actual utilization rate of resources is low, resulting in a huge waste of investment.

3.4. Motivation and Collaboration Challenges in Building a Modular Service Ecosystem

To build a sustainable "module as a service" ecosystem, it is necessary for the teaching community to transform from producers of course content to designers, contributors and maintainers of modular services. However, under the current evaluation orientation of "emphasizing research over teaching" prevalent in colleges and universities, teachers spend a lot of time on refined module development and sharing, and their labor value is difficult to be fully reflected in professional title evaluation and performance assessment, resulting in insufficient motivation to participate. At the same time, the standardization of modules requires cross-departmental, cross-college and even cross-university collaboration, involving complex coordination of interests and the formulation of unified technical specifications, which is difficult to organize. Due to the lack of an effective closed-loop mechanism of crowdfunding, sharing, evaluation and incentives, modular construction is prone to become a one-off project or a "personal show" of a few teachers, and it is difficult to form economies of scale and ecological vitality.

4. Construction Strategies for "Module-as-a-Service" Computer Network Courses

The aforementioned analysis indicates that the reform of computer network courses can no longer be confined to partial, piecemeal fixes but requires a systematic paradigm reconstruction. Based on a problem-oriented approach, this section systematically elaborates the specific strategic system for "Module as a Service" style course construction, providing a clear implementation path for the transition from the traditional "textbook-centric" model to the new "learning-service-centric" model.

4.1. Top-Level Design: Constructing an Overall "Value-Standard-Path" Architecture

1) Value positioning refers to establishing the dual goals of "student-centered and teacher-empowered". The core value of the new model lies in dual-path empowerment: on the one hand, by providing precise services to learners to enhance their learning outcomes and professional competitiveness; On the other hand, by providing reusable high-quality modules and service tools, teachers are freed from repetitive content production and focused on teaching innovation and advanced interaction.

2) The standard system refers to the establishment of a three-dimensional standard framework of "content and knowledge, service and interface, quality and evaluation". Among them, the content and knowledge standard system, drawing on the idea of domain knowledge modeling, formulates the classification and coding standards of knowledge elements in computer network teaching, ensuring the logical consistency of knowledge across modules and courses from the root, and laying the semantic foundation for intelligent combination; The service and interface standard system formulates the teaching service module encapsulation and interface specification, so that any module that conforms to the specification can be identified, scheduled and flexibly combined indiscriminately, achieving true plug and play; The quality and evaluation standard system classifies modules based on dimensions such as scientificity, cutting-edge nature, and teaching applicability through module quality standards, and evaluates the effectiveness of "services" through teaching service effect evaluation indicators based on teaching process data and result data, forming a closed-loop quality management mechanism of "construction, application, evaluation, improvement".

3) The implementation path refers to the progressive strategy of "pilot breakthrough, iterative optimization, and radiative promotion". Priority will be given to course teams with a solid foundation for teaching reform and a strong willingness to carry out pilot modular transformation of core chapters. In the pilot, prioritize the construction of "high consensus, high reuse" basic modules and "prominent pain points" characteristic application modules to quickly form core service capabilities and verify the effectiveness of the model. Based on the pilot experience, revise and optimize the standard system and promotion strategy, and then gradually expand to all courses, all specialties and related course groups.

4.2. Resource Reconstruction: Creating a Systematic, Reusable, Composable, and Evolvable Module Set

1) "Domain-Driven" Standardized Decomposition. Based on computer network domain knowledge and employing instructional analysis techniques, the course system is systematically decomposed into functionally cohesive "micro-modules." For example, the "TCP/IP Protocol Stack" can be decomposed into a series of independent modules such as "IP Addressing and Subnetting," "IP Datagram Forwarding," "TCP Connection Establishment and Release," and "Congestion Control Algorithms." Each module contains components like core explanations, study

guides, formative exercises, application scenarios/cases, and extended readings.

2) "Multi-Dimensional Tagging" for Refined Encapsulation. Each module is tagged with rich semantic labels to build a multi-dimensional indexing system. Label dimensions include the belonging knowledge domain, technical keywords, Bloom's taxonomy level, difficulty coefficient, estimated study time, prerequisite dependent modules, and applicable professional scenarios. This lays the foundation for subsequent intelligent retrieval and combination.

3) "Visual Drag-and-Drop" for Agile Assembly. A graphical course assembly platform should be developed for teachers. Based on teaching objectives—for example, constructing a network programming knowledge module combination for software engineering majors—teachers can quickly assemble and generate personalized course learning path maps by filtering tags and using visual drag-and-drop within the module repository. The platform provides logic validation functions, automatically suggesting dependency relationships and sequence recommendations between modules.

4.3. Service Innovation: Achieving Agile Response, Intelligent Adaptation, and Precise Supply for Personalized Delivery

1) With "Agile Response" as the cornerstone, it is necessary to create a new "Module as a Service" paradigm that is schedulable, composable, and one-click invocable. The traditional siloed storage and usage model of teaching resources should be abandoned. The constructed standardized teaching modules need to be encapsulated into standardized service interfaces that can be independently published, remotely invoked, and version-managed, thereby fully realizing "Module as a Service." Relying on a unified module service management platform, flexible invocation and system integration can be supported. A teaching service unit system covering the entire chain of knowledge impartation, experimental training, case teaching, and competency assessment should be constructed to ensure real-time and stable service response. This approach promotes the evolution of teaching resources from static repositories to agilely invoked service applications.

2) With "Intelligent Adaptation" as the core, it is recommended to build an intelligent recommendation engine based on user profiles and learning paths[5]. Key attributes such as teacher role, target audience, course objectives, and teaching scenarios should be collected and analyzed in real-time to dynamically identify teaching service needs, achieving precise profiling and intelligent matching of teaching resources. Through deep learning and multi-dimensional data fusion analysis, optimal knowledge module combinations, suitable teaching cases, matching PaaS-level experimental environment configurations, and personalized teaching strategies can be automatically recommended. One-click invocation, automatic deployment, and rapid startup should be enabled, truly achieving on-demand, intelligent teaching support.

3) With "Precise Supply" as the goal, it is essential to construct a full-link service delivery system that supports multiple scenarios, multiple terminals, and high responsiveness. Through servitization mechanisms, compatibility with various teaching models such as online teaching, blended learning, and project-driven teaching should be ensured[4]. Seamless access across terminals, platforms, and systems needs to be supported. Fine-grained scheduling of resource supply should be achieved, promoting the development of service supply towards precision. This approach fundamentally changes the inefficient resource acquisition mode of "teachers searching on their own, students receiving passively." The precise push and efficient reuse of teaching resources can be realized, significantly improving resource usage efficiency and teaching adaptation accuracy.

4.4. Ecosystem Cultivation: Establishing a Sustainable Development Mechanism Based on Crowdsourcing, Open Sharing, and Feedback Loop

1) Guided by the principle of "Crowdsourced Construction," it is suggested to decompose modular construction tasks to jointly build the "Module as a Service" foundation for computer network-related courses. Addressing current real bottlenecks such as insufficient teacher collaboration, frequent resource silos, and implementation difficulties in modular course development, the habit of solitary teaching should be broken. A "responsibility field" system for course module construction needs to be established. Cross-disciplinary, cross-unit modular teaching teams should be formed based on course clusters, implementing a co-construction model led by principal responsible teachers with participation from collaborating teachers and collective review and approval. Clear responsibility lists and contribution recognition rules must be defined to promote the collaborative construction of the "Module as a Service" foundation for computer network courses, centered around course knowledge bases, teaching method libraries, and teaching condition libraries.

2) Guided by the principle of "Sharing and Common Use," it is necessary to fully leverage the service benefits of the "Module as a Service" model for computer network courses. In the construction and implementation of various computer network courses at different levels and for different majors, a benefit point mechanism should be adopted to encourage teachers to widely use "intelligent" recommendation service methods and tools for lesson preparation and teaching, based on the constructed course knowledge bases, teaching method libraries, and teaching condition libraries. The supporting role of teaching resources such as course question banks, auxiliary teaching materials, and experimental software/hardware platform resources should be fully utilized. This approach addresses problems like high lesson preparation difficulty for teachers, insufficient adaptability of course design, challenges in precisely aligning with learning conditions, and low comprehensive utilization efficiency of course resources. The service benefits of the "Module as a Service" model for computer network courses can be maximized, enhancing the sense of accomplishment for teaching instructors.

3) Using the "Feedback Loop" as a means, it is recommended to stimulate the momentum for the "ecological" construction of computer network courses[7]. On one hand, module construction achievements should be incorporated into the teaching performance assessment system, realizing "more work, more reward; better performance, better pay." On the other hand, a resource usage point system should be established to encourage teachers to actively contribute high-quality resources and participate in cross-course invocation and iterative optimization. Simultaneously, a module service catalog and resource invocation ledger should be constructed, supporting teachers in combining resource modules in an on-demand, "à la carte" manner, thereby achieving a virtuous cycle of "build once, use multiple times, and continuously optimize."

5. Conclusion and Prospect

In response to the urgent need for the reform of computer network courses in the context of new engineering construction in higher education, this study systematically constructs a new model of "module as a service" for course construction. The model aims to systematically address deep-seated problems such as slow update of course content, insufficient precision of teaching adaptation, low efficiency of resource utilization and lack of motivation for collaborative construction through strategic synergy in four dimensions: top-level architecture design, modular resource reconstruction, intelligent service innovation and sustainable ecosystem cultivation. The essence is to drive the transformation of the curriculum form from the static, closed, and unified "textbook-centered" paradigm to the dynamic, open, and personalized "learning service center" paradigm. Practice has

shown that the success of "module as a service" curriculum construction depends not only on the support of the technology platform, but also on the recognition of the innovative value of teaching by educational administrators, the reasonable evaluation of teachers' input, and the cultivation of an open, collaborative and shared culture in the teacher-student community. This is undoubtedly a systematic project, but it represents the direction that higher education courses must move in to meet the challenges of The Times and to cultivate future innovative talents.

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