



UNIVERSITY OF WEST ATTICA
FACULTY OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Diploma Thesis

**Design and implementation of knowledge assessment framework in Computer
Networks for University students**

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ATHENS-EGALEO, February 2024



ΠΑΝΕΠΙΣΤΗΜΙΟ ΔΥΤΙΚΗΣ ΑΤΤΙΚΗΣ
ΣΧΟΛΗ ΜΗΧΑΝΙΚΩΝ
ΤΜΗΜΑ ΗΛΕΚΤΡΟΛΟΓΩΝ & ΗΛΕΚΤΡΟΝΙΚΩΝ ΜΗΧΑΝΙΚΩΝ

Διπλωματική Εργασία

**Σχεδιασμός και υλοποίηση πλαισίου αξιολόγησης γνώσεων φοιτητών στο
αντικείμενο των Δικτύων Υπολογιστών**

Φοιτητής: Κυπαρίσσης Χάρης
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Επιβλέπων Καθηγητής

ΧΑΡΑΛΑΜΠΟΣ ΠΑΤΡΙΚΑΚΗΣ
Καθηγητής στο Τμήμα Ηλεκτρολόγων Και Ηλεκτρονικών Μηχανικών

ΑΘΗΝΑ-ΑΙΓΑΛΕΩ, Φεβρουάριος 2024

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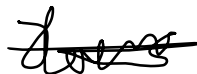
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Ο Δηλών
Κυπαρίσσης Χάρης



Abstract

The field of computer networks is in constant development, involving the interconnection of computer systems through various technologies. The education of new engineers in this domain holds significant importance. This specific diploma thesis conducts investigation into existing learning tools and certifications offered by various agencies. The goal is to create an application that aids students in assessing their knowledge of computer networks, while enabling teachers to pinpoint their students' knowledge gaps accurately. Consequently, students will be well-prepared to participate in the certification exams they are interested in.

Keywords

Computer Networks, Learning Tool, Application Development, Certification, Exam

Περίληψη

Το πεδίο των δικτύων υπολογιστών, είναι ένα συνεχώς αναπτυσσόμενο πεδίο, που αφορά στην διασύνδεση υπολογιστικών συστημάτων με την χρήση διαφόρων τεχνολογιών. Η εκμάθηση νέων μηχανικών στο πεδίο αυτό παίζει σημαντικό ρόλο. Η συγκεκριμένη διπλωματική εργασία ερευνά ήδη υπάρχοντα εργαλεία εκμάθησης, καθώς και πιστοποιήσεις που προσφέρουν οι διάφοροι φορείς. Συνεπώς, στόχος είναι η δημιουργία μιας εφαρμογής που θα βοηθάει τους φοιτητές να εξετάζουν τις γνώσεις τους πάνω στα δίκτυα υπολογιστών, και τους καθηγητές να μπορούν να στοχεύουν με ακρίβεια στα γνωστικά κενά των φοιτητών τους. Έτσι, οι φοιτητές θα μπορούν να προετοιμάζονται κατάλληλα για να λάβουν μέρος στις εξετάσεις της πιστοποίησης που τους ενδιαφέρει.

Λέξεις – κλειδιά

Δίκτυα υπολογιστών, Εργαλείο εκμάθησης, Ανάπτυξη εφαρμογής, Πιστοποίηση, Εξέταση

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1. Introduction

Computer networking has become an essential part of modern life as our world becomes increasingly interconnected. This has created a high demand for trained professionals in the field of computer networks who are skilled in managing and maintaining complex network infrastructures. The constant evolution of network technologies and protocols requires a rigorous and ongoing training process to keep up with the latest trends.

To meet this growing need for skilled network professionals, various training programs and certifications have been developed by leading technology companies such as Cisco, Microsoft, Oracle, and others. These programs aim to provide comprehensive knowledge and skills in computer network technologies and prepare individuals for various roles in the industry.

There are a lot of training programs that someone may have. Computer network certificates are considered to be highly valuable for anyone that wish to achieve a career as an IT professional. These certificates are designed to offer specialized skills for individuals in diverse network technology sectors. Candidates are able to acquire a solid foundation to enter the competitive job market of the field. Certifications in computer networks not only enhances the skill knowledge of the candidate, but they also provide a solid testament about their expertise. This is very important, because it provides the tools necessary to classify the skills of potential employees.

Success in any certification requires a methodical study and preparation process that is time-consuming and challenging. To help candidates prepare for the final exams, an online application has been developed that provides a comprehensive set of features for practice and preparation.

1.1. Object of the Diploma Thesis

This diploma thesis endeavors to address the critical need for an effective knowledge assessment framework tailored specifically for university students studying Computer Networks. In an era of rapidly evolving technology, it is imperative to ensure that students possess a comprehensive understanding of network principles and protocols. This research aims to design, develop, and implement a robust assessment framework that supports theoretical examinations. By leveraging modern pedagogical techniques and emerging technologies, this framework seeks to enhance the

learning experience for students while providing instructors with a reliable tool to gauge comprehension and proficiency.

1.2. Purpose and objectives

The purpose of this thesis is to design and develop an application that supports knowledge contests in computer network technologies. The application is an online portal that can be executed on a computer, either locally or remotely. It contains competitions on computer networks that can evaluate a student's level of knowledge in different computer network sections. The application provides multiple-choice and matching questions, just like the most common certification tests, and allows professors to upload questions categorized based on the section and degree of difficulty.

The application has two categories of users: administrators and professors-experts who manage users and upload questions, respectively, and users who register to prepare for the exams. Users can take a test that has the same ratio of 33% per section with 70 questions each test. The application enables users to activate a timer for 1.5 hours to complete the test and know their score. Users also have a history tab that shows their performance, the dates they took each test, the questions they got wrong, the correct answer, and the explanation of the correct answer.

Overall, the purpose of this thesis is to provide an online application that can help students prepare for any computer network certification and become competent networking professionals. The application can also serve as a standard for other certifications from leading technology companies. By using this application, students can enhance their knowledge and skills, and the industry can obtain competent networking professionals who have advanced protocol knowledge to meet the ever-increasing demands of the market.

1.3. Methodology

The methodology of the thesis commences with an exploration of existing learning tools for students in the field of network computing. Therefore, it is imperative to gain an understanding of the certifications provided by various companies and agencies. Utilizing this knowledge, the specifications and objectives of the application are formulated. Subsequently, the application is

developed to assist students in enhancing their understanding and adequately preparing for success in their desired certification examinations.

1.4. Innovation

The application conceived in this thesis seeks to rectify prevalent shortcomings in the educational tools accessible to students and certification candidates specializing in computer networks. It not only empowers professors to pinpoint and bridge gaps in their students' understanding but also serves as a vital tool for self-assessment and improvement. By providing a comprehensive platform, it equips students with the means to meticulously prepare for their examinations, thereby fostering a more effective and enriching learning experience.

1.5. Structure

This thesis consists of five chapters. The first chapter introduces the topic, provides an overview of computer networking training, and highlights the importance of training in computer network technologies. The second chapter presents various training programs and certifications in computer network technologies. The third chapter reviews existing educational applications in computer network technologies, including network simulators, emulators, and online learning platforms. The fourth chapter provides a practical part, which details the application's purpose, development methodology, and tools used for implementation. Finally, the last chapter concludes the thesis and provides an overall assessment of the application's potential impact.

2. CHAPTER 1st: Training in Computer Network Technologies

2.1. Computer Network Technologies

Computer Network Technologies (Wetherall & Tanenbaum, 2013; Sunshine, 2013) refer to the various methods and protocols used to connect and communicate between different devices and systems on a network. The main purpose of computer networks is to share resources and information among connected devices. These resources can include hardware, software, and data, and the networks can vary in size and complexity (Peterson & Davie, 2007).

Various computer network technologies exist, each boasting distinct attributes and applications. Among the most prevalent are local area networks (LANs), wide area networks (WANs), and wireless networks (Wetherall & Tanenbaum, 2013; Sunshine, 2013).

A Local Area Network (LAN) (Wetherall & Tanenbaum, 2013; Sunshine, 2013) refers to a form of computer network that links devices within a confined geographical space, like a residence, workplace, or facility. LANs are commonly employed to interconnect computers, printers, and other proximate devices. They can be established through either wired or wireless connections and are frequently utilized for the purpose of resource sharing, including files, printers, and internet connectivity.

A Wide Area Network (WAN) (Sunshine, 2013) is a category of computer network that links devices across an extensive geographic expanse, encompassing areas like cities, states, or even spanning multiple countries. WANs are predominantly employed to interconnect numerous LANs, facilitating the exchange of resources and information. Illustrative instances of WANs encompass the internet, which interlinks millions of devices globally, and corporate networks that join multiple company offices and branches.

Wireless networks constitute a category of computer network that links devices devoid of physical cabling. Instead, they rely on radio waves for data transmission between devices. These networks can facilitate connections within confined spaces like homes or offices, or over expansive regions like cities or even spanning multiple countries. The primary utility of wireless networks is often to link mobile devices, such as smartphones and laptops, to the internet.

Cloud computing stands as another variant of computer network technology, signifying the utilization of distant servers for data storage, management, and processing, as opposed to a local server or personal computer. This paradigm empowers users to reach their files and applications from any location equipped with an internet connection. Furthermore, it facilitates seamless collaboration and resource-sharing among numerous users (Goyal & Dadizadeh, 2009). There are also virtual private networks (VPNs) and Software-defined networks (SDN), which are used to improve the security and flexibility of networks. VPNs (Feng, 2014) provide a secure, encrypted connection between devices over the internet, while SDN (Rana et al., 2019) allows network administrators to manage and configure network devices using software, rather than manual configuration.

To encapsulate, computer network technologies encompass diverse approaches and protocols employed for interconnecting and facilitating communication among distinct devices and systems within a network. Prominent categories encompass local area networks (LANs), wide area networks (WANs), wireless networks, cloud computing, virtual private networks (VPNs), and Software-defined networks (SDN). Each of these network types possesses distinct attributes and applications, serving as conduits for the exchange of resources and information among interconnected devices.

2.2. Importance of Training in Computer Network Technologies

Training in computer network technologies is essential for professionals working in the field of networking as well as for those who want to pursue a career in this field (Yalcin et al., 2015). The importance of training in computer network technologies can be summarized in several key points:

Primarily, education in computer network technologies furnishes the requisite knowledge and competencies for crafting, executing, and sustaining computer networks. This encompasses proficiency in comprehending the principles, technologies, and protocols underpinning networking, including network architecture, internet protocols, network security, and network rectification (Sunshine, 2013).

Secondly, instruction in computer network technologies ensures that professionals remain abreast of the most recent advancements and optimal methodologies in the field. This is crucial given the

perpetual emergence of new technologies and trends, necessitating professionals to adeptly navigate and integrate these shifts (Morris et al., 2012).

Thirdly, training in computer network technologies can open up a wide range of career opportunities. A solid understanding of computer network technologies is in high demand in many industries, including technology, finance, healthcare, and government. Additionally, many companies require certifications as a minimum qualification for certain positions (Morris et al., 2012).

Fourthly, training in computer network technologies can help professionals to improve their problem-solving skills. Networking is a field that requires a lot of troubleshooting and problem-solving skills, and training in computer network technologies can help professionals develop these skills (Jakab et al., 2009).

Fifthly, hands-on experience is an important aspect of training in computer network technologies. This can be obtained through internships, real-world projects or even working on personal projects. It provides an opportunity to apply the concepts and skills learned in a practical setting, which can be a valuable asset when seeking employment or working on real-world networks (Sarkar, 2006).

In the grand scheme of things, instruction in computer network technologies proves indispensable for professionals engaged in the realm of networking, and for aspiring individuals looking to carve a path in this domain. It furnishes the requisite expertise to conceive, execute, and sustain computer networks, ensures professionals remain abreast of cutting-edge technologies and optimal methodologies, unlocks a vast array of career prospects, and hones problem-solving abilities while affording hands-on experience via internships, real-world ventures, or personal undertakings (Sarkar, 2006).

2.3. Training in Computer Network Technologies

Education in computer network technologies encompasses the acquisition of knowledge pertaining to the principles, technologies, and protocols instrumental in crafting, executing, and sustaining computer networks. This spans areas such as network architecture, internet protocols, network security, and network rectification.

Instructional avenues for this training may encompass traditional classroom environments, online courses, or independent study utilizing textbooks and supplementary resources. Noteworthy certifications in this domain encompass the Cisco Certified Network Associate (CCNA), CompTIA Network+, SolarWinds, WCNA, Citrix, Juniper Networks, F5 Networks, Amazon Web Services, Google Cloud, Microsoft Azure, VCP6-DCV VMware, and ITIL.

2.3.1. Cisco Certified Network Associate

The Cisco Certified Network Associate (CCNA) certification program, extended by Cisco Systems, a prominent provider of networking infrastructure and software, aims to authenticate proficiency in the installation, configuration, and resolution of issues pertaining to Cisco network devices. This certification attests to the individual's competence in these crucial aspects.

The CCNA certification serves as a fundamental accreditation for individuals aspiring to pursue a career in networking. It encompasses an extensive array of subjects, spanning routing, switching, and network security. Furthermore, it serves as a prerequisite for numerous higher-level Cisco certifications, underscoring its pivotal role in the certification hierarchy.

Indeed, the CCNA certification program is subdivided into various specialized tracks, encompassing CCNA Routing and Switching, CCNA Security, CCNA Service Provider, CCNA Data Center, and CCNA Wireless. Each track hones in on distinct facets of networking and necessitates successful completion of a corresponding examination. This structure allows individuals to tailor their certification to align with their specific areas of interest and expertise.

To earn the CCNA certification, candidates must pass one or more exams, depending on the specific track they choose. The exams are designed to test knowledge and skills in areas such as routing and switching, network security, and wireless networking. The exams are multiple-choice and consist of both theory and simulation-based questions. The CCNA certification is valid for three years and can be renewed by passing the current CCNA exam or by achieving a higher-level Cisco certification.

2.3.2. CompTIA Network+

CompTIA Network+ is a vendor-neutral certification program that substantiates proficiency in troubleshooting, configuring, and overseeing prevalent network infrastructure. Tailored for IT professionals in roles such as network administrator, network technician, or network installer, it encompasses a comprehensive spectrum of subjects. These include network technologies, installation and configuration, media and topologies, management, as well as security. This certification is highly regarded for its relevance across various technology platforms and environments.

Attaining the CompTIA Network+ certification mandates the successful completion of a single examination. This assessment is meticulously crafted to evaluate candidates' proficiency in domains like network architecture, network operations, network security, and network troubleshooting. The exam format encompasses multiple-choice questions and includes both theoretical and performance-based inquiries, ensuring a comprehensive evaluation of the candidate's knowledge and practical skills.

The CompTIA Network+ certification stands out as an excellent entry point for individuals embarking on a career in networking, and it holds significant industry-wide recognition as a valuable credential. Additionally, it proves beneficial for professionals operating in domains like security, cloud computing, and data storage. Furthermore, it serves as a stepping stone for those considering the pursuit of more advanced certifications such as the Cisco Certified Network Professional (CCNP) or Microsoft Certified: Azure Administrator Associate. This versatility underscores its relevance across a broad spectrum of IT specializations.

The CompTIA Network+ certification holds a validity period of three years. To maintain its active status, individuals have the option to either pass the latest Network+ exam or attain a higher-level CompTIA certification, demonstrating ongoing proficiency and expertise in the field of networking. This flexibility provides certified professionals with multiple avenues for ensuring their credentials remain up-to-date and relevant in the ever-evolving IT landscape.

In summary, the CompTIA Network+ certification holds broad industry recognition as a vendor-neutral validation of proficiency in troubleshooting, configuring, and overseeing standard network

infrastructure. It serves as a gateway to a diverse array of career prospects within the networking domain, underlining its significance in the professional IT landscape.

2.3.3. SolarWinds

SolarWinds is a leading provider of IT management software, offering a wide range of IT solutions to manage networks, systems, and security (Dissmeyer, 2013). As part of its commitment to empowering IT professionals with the skills and knowledge they need to succeed, SolarWinds offers several certifications.

One of these certifications is the SolarWinds Certified Professional (SCP) program¹. This certification is designed for individuals who are interested in demonstrating their expertise in using SolarWinds products. The SCP program covers a range of SolarWinds products, including the Orion Platform (Sterle & Bhunia, 2021), Network Performance Monitor (Dissmeyer, 2013), and other key solutions.

To become certified, individuals must pass a certification exam that covers the installation, configuration, and use of SolarWinds products. The exam is designed to assess a candidate's knowledge of SolarWinds products and their ability to effectively use these products in real-world scenarios.

The SCP certification (Deveriya, 2005) is an important tool for IT professionals who want to demonstrate their expertise and stay ahead of the curve in the rapidly evolving field of IT management. By earning this certification, individuals can show that they have a deep understanding of SolarWinds products and are able to use them effectively to address the needs of their organizations.

To sum up, the SolarWinds Certified Professional (SCP) certification is a valuable credential for IT professionals aiming to showcase their proficiency in utilizing SolarWinds products. This certification offers a thorough evaluation of an individual's knowledge and abilities, serving as an effective means to stay current with the latest advancements in the realm of IT management.

¹ <https://support.solarwinds.com/solarwinds-certified-professional-program>

2.3.4. WCNA

The Certified Wireless Network Administrator (WCNA)² certification is a professional credential designed for IT professionals who specialize in wireless network administration. The WCNA certification is offered by the Wireless Technology Forum (WTF), a non-profit organization dedicated to promoting wireless technology and professional development (Coleman & Westcott, 2012).

The WCNA certification is crafted to evaluate an individual's proficiency and understanding of wireless networking. This certification encompasses a diverse array of subjects, consisting of wireless network design, security, performance, and management. Attaining this certification necessitates passing a rigorous exam that assesses both theoretical knowledge and the application of this knowledge in practical, real-world scenarios (Carpenter & Barrett, 2007).

The WCNA certification stands as a notable demonstration of an individual's proficiency in wireless networking. Attaining this certification signifies a comprehensive grasp of wireless networking principles and the ability to apply them effectively in practical scenarios. This accolade holds substantial value for individuals seeking career progression within the IT industry and for organizations seeking to recruit adept and well-versed IT professionals. It serves as a testament to an individual's competence and expertise in the domain of wireless networking.

In addition to demonstrating expertise, the WCNA certification also provides individuals with opportunities for professional development. By participating in the certification program, individuals can stay up-to-date with the latest developments in the field of wireless networking and continue to build their knowledge and skills.

To sum up, the Certified Wireless Network Administrator (WCNA) certification proves instrumental for IT professionals specializing in wireless network administration. This certification offers a thorough evaluation of an individual's proficiency and expertise, serving as

² <https://www.cwnp.com/certifications/cwna>

an effective means to stay abreast of the latest advancements in the field of wireless networking. It stands as a valuable credential in affirming one's capabilities in this specialized domain.

2.3.5. Citrix

Citrix³ is a leading provider of virtualization, networking, and cloud computing solutions. As part of its commitment to empowering IT professionals with the skills and knowledge they need to succeed, Citrix offers several certifications.

One of these certifications is the Citrix Certified Professional (CCP) program. This certification is designed for individuals who are interested in demonstrating their expertise in using Citrix products. The CCP program covers a range of Citrix products, including XenApp, XenDesktop, XenServer, and other key solutions.

To become certified, individuals must pass a certification exam that covers the installation, configuration, and use of Citrix products. The exam is designed to assess a candidate's knowledge of Citrix products and their ability to effectively use these products in real-world scenarios (Messmer, 2004).

The CCP certification is an important tool for IT professionals who want to demonstrate their expertise and stay ahead of the curve in the rapidly evolving field of virtualization, networking, and cloud computing. By earning this certification, individuals can show that they have a deep understanding of Citrix products and are able to use them effectively to address the needs of their organizations.

In conclusion, the Citrix Certified Professional (CCP) certification is a valuable tool for IT professionals who are looking to demonstrate their expertise in using Citrix products. The certification provides a comprehensive assessment of an individual's knowledge and skills, and is a great way for individuals to stay up-to-date with the latest developments in the field of virtualization, networking, and cloud computing.

³ <https://www.citrix.com/>

2.3.6. Juniper Networks

Juniper Networks⁴ is a leading provider of networking and security solutions for organizations of all sizes. As part of its commitment to empowering IT professionals with the skills and knowledge they need to succeed, Juniper Networks offers several certifications.

One of these certifications is the Juniper Networks Certified Internet Associate (JNCIA) program⁵. This certification is designed for individuals who are interested in demonstrating their expertise in using Juniper Networks products. The JNCIA program covers a range of Juniper Networks products, including routers, switches, and security devices (Soricelli et al., 2003).

To become certified, individuals must pass a certification exam that covers the installation, configuration, and use of Juniper Networks products. The exam is designed to assess a candidate's knowledge of Juniper Networks products and their ability to effectively use these products in real-world scenarios.

The JNCIA certification is an important tool for IT professionals who want to demonstrate their expertise and stay ahead of the curve in the rapidly evolving field of networking and security. By earning this certification, individuals can show that they have a deep understanding of Juniper Networks products and are able to use them effectively to address the needs of their organizations.

In addition to the JNCIA program, Juniper Networks offers several other certifications that are designed to assess an individual's expertise in using Juniper Networks products at a more advanced level. These certifications provide a clear career path for IT professionals who are looking to build their skills and advance their careers in the field of networking and security.

To sum up, the Juniper Networks Certified Internet Associate (JNCIA) certification serves as a pivotal asset for IT professionals seeking to showcase their proficiency in utilizing Juniper Networks products. This certification offers a thorough evaluation of an individual's knowledge and skills, providing an effective means to remain current with the latest advancements in the

⁴ <https://www.juniper.net/>

⁵ <https://www.juniper.net/us/en/training/certification/tracks/junos/jncia-junos.html>

dynamic fields of networking and security. It stands as a valuable credential attesting to an individual's expertise in leveraging Juniper Networks solutions.

2.3.7. F5 Networks

F5 Networks⁶ is a leading provider of application delivery and security solutions for organizations of all sizes. As part of its commitment to empowering IT professionals with the skills and knowledge they need to succeed, F5 Networks offers several certifications.

One of these certifications is the F5 Certified Technology Specialist (F5-CTS) program ⁷. This certification is designed for individuals who are interested in demonstrating their expertise in using F5 Networks products. The F5-CTS program covers a range of F5 Networks products, including application delivery controllers (ADCs), security solutions, and other key products.

To become certified, individuals must pass a certification exam that covers the installation, configuration, and use of F5 Networks products. The exam is designed to assess a candidate's knowledge of F5 Networks products and their ability to effectively use these products in real-world scenarios.

The F5-CTS certification holds significant value for IT professionals seeking to validate their expertise in the dynamic realms of application delivery and security. This certification serves as a testament to an individual's profound understanding of F5 Networks products and their adeptness in applying them to meet organizational requirements. It stands as a potent credential, showcasing an individual's proficiency in leveraging F5 Networks solutions to address the evolving demands of their organizations.

In addition to the F5-CTS program, F5 Networks offers several other certifications that are designed to assess an individual's expertise in using F5 Networks products at a more advanced level. These certifications provide a clear career path for IT professionals who are looking to build their skills and advance their careers in the field of application delivery and security.

⁶ <https://www.f5.com/>

⁷ <https://www.f5.com/services/certification>

In conclusion, the F5 Certified Technology Specialist (F5-CTS) certification is a valuable tool for IT professionals who are looking to demonstrate their expertise in using F5 Networks products. The certification provides a comprehensive assessment of an individual's knowledge and skills, and is a great way for individuals to stay up-to-date with the latest developments in the field of application delivery and security.

2.3.8. Amazon Web Services

Amazon Web Services (AWS) is a leading cloud computing platform that provides a wide range of services for organizations of all sizes. As part of its commitment to empowering IT professionals with the skills and knowledge they need to succeed, Amazon Web Services offers several certifications (Mathew & Varia, 2014).

One of these certifications is the AWS Certified Solutions Architect program. This certification is designed for individuals who are interested in demonstrating their expertise in using AWS cloud computing services. The AWS Certified Solutions Architect program covers a range of AWS services, including computing, storage, database, and security (Baron et al., 2016).

To become certified, individuals must pass a certification exam that covers the design and implementation of AWS services. The exam is designed to assess a candidate's knowledge of AWS services and their ability to effectively use these services in real-world scenarios.

The AWS Certified Solutions Architect certification is an important tool for IT professionals who want to demonstrate their expertise and stay ahead of the curve in the rapidly evolving field of cloud computing. By earning this certification, individuals can show that they have a deep understanding of AWS services and are able to use them effectively to address the needs of their organizations.

In addition to the AWS Certified Solutions Architect program, Amazon Web Services offers several other certifications that are designed to assess an individual's expertise in using AWS services at a more advanced level. These certifications provide a clear career path for IT professionals who are looking to build their skills and advance their careers in the field of cloud computing (Chauhan et al., 2018).

In conclusion, the AWS Certified Solutions Architect certification is a valuable tool for IT professionals who are looking to demonstrate their expertise in using Amazon Web Services cloud computing services. The certification provides a comprehensive assessment of an individual's knowledge and skills, and is a great way for individuals to stay up-to-date with the latest developments in the field of cloud computing.

2.3.9. Google Cloud

Google Cloud is a leading cloud computing platform that provides a wide range of services for organizations of all sizes. As part of its commitment to empowering IT professionals with the skills and knowledge they need to succeed, Google Cloud offers several certifications (Garraghan et al., 2013).

One prominent certification in this domain is the Google Certified Professional Cloud Architect program. Tailored for individuals looking to showcase their proficiency in leveraging Google Cloud services, this certification encompasses a wide array of offerings. It delves into various Google Cloud services, encompassing computing, storage, database, and security. This program is specifically designed to validate an individual's expertise in architecting solutions using Google Cloud technologies.

To become certified, individuals must pass a certification exam that covers the design and implementation of Google Cloud services. The exam is designed to assess a candidate's knowledge of Google Cloud services and their ability to effectively use these services in real-world scenarios (Korobeinikova et al., 2020).

The Google Certified Professional Cloud Architect certification stands as a significant asset for IT professionals striving to validate their expertise in the swiftly progressing realm of cloud computing. Achieving this certification attests to an individual's profound comprehension of Google Cloud services and their adeptness in leveraging them to meet organizational requirements. It serves as a robust credential, affirming an individual's proficiency in architecting solutions utilizing Google Cloud technologies (Sullivan, 2019).

In addition to the Google Certified Professional Cloud Architect program, Google Cloud offers several other certifications that are designed to assess an individual's expertise in using Google Cloud services at a more advanced level. These certifications provide a clear career path for IT professionals who are looking to build their skills and advance their careers in the field of cloud computing.

To sum up, the Google Certified Professional Cloud Architect certification is a pivotal asset for IT professionals seeking to showcase their proficiency in leveraging Google Cloud services. This certification offers a thorough evaluation of an individual's knowledge and skills, providing an effective means to remain current with the latest advancements in the dynamic field of cloud computing. It stands as a valuable credential attesting to an individual's expertise in architecting solutions using Google Cloud technologies.

2.3.10. Microsoft Azure

Microsoft Azure is a leading cloud computing platform that provides a wide range of services for organizations of all sizes. As part of its commitment to empowering IT professionals with the skills and knowledge they need to succeed, Microsoft Azure offers several certifications (Wilder, 2012).

One of these certifications is the Microsoft Certified: Azure Administrator Associate program (Washam et al., 2019). This certification is designed for individuals who are interested in demonstrating their expertise in using Microsoft Azure services. The Microsoft Certified: Azure Administrator Associate program covers a range of Microsoft Azure services, including computing, storage, database, and security.

To become certified, individuals must pass a certification exam that covers the design and implementation of Microsoft Azure services. The exam is designed to assess a candidate's knowledge of Microsoft Azure services and their ability to effectively use these services in real-world scenarios.

The Microsoft Certified: Azure Administrator Associate certification is an important tool for IT professionals who want to demonstrate their expertise and stay ahead of the curve in the rapidly evolving field of cloud computing. By earning this certification, individuals can show that they

have a deep understanding of Microsoft Azure services and are able to use them effectively to address the needs of their organizations (Network & CompTIA, 2021).

In addition to the Microsoft Certified: Azure Administrator Associate program, Microsoft Azure offers several other certifications that are designed to assess an individual's expertise in using Microsoft Azure services at a more advanced level. These certifications provide a clear career path for IT professionals who are looking to build their skills and advance their careers in the field of cloud computing.

To sum up, the Microsoft Certified: Azure Administrator Associate certification is a significant asset for IT professionals aiming to showcase their proficiency in utilizing Microsoft Azure services. This certification offers a thorough evaluation of an individual's knowledge and skills, providing an effective means to remain current with the latest advancements in the dynamic field of cloud computing. It stands as a valuable credential attesting to an individual's expertise in administering Azure solutions.

2.3.11. VCP6-DCV

VCP6-DCV, or VMware Certified Professional 6 - Data Center Virtualization, is a certification program offered by VMware, a leading provider of virtualization and cloud computing technologies. The VCP6-DCV certification is designed for IT professionals who are interested in demonstrating their expertise in using VMware vSphere, a virtualization platform for data center management. (Davis et al., 2016)

The VCP6-DCV certification covers a range of vSphere technologies, including virtual machine management, network virtualization, storage virtualization, and security. To become certified, individuals must pass a certification exam that covers the design and implementation of vSphere technologies. The exam is designed to assess a candidate's knowledge of vSphere and their ability to effectively use these technologies in real-world scenarios (Hall & Andrews, 2020).).

The VCP6-DCV certification holds significant value for IT professionals seeking to validate their expertise in the swiftly evolving domains of virtualization and cloud computing. This certification affirms an individual's profound understanding of vSphere and their capability to effectively

leverage it to meet organizational requirements. It serves as a robust credential, showcasing an individual's proficiency in deploying and managing virtualized environments (Ferguson, 2016).

Indeed, alongside the VCP6-DCV certification, VMware presents a range of additional certifications tailored to evaluate an individual's proficiency in deploying and managing vSphere and other VMware technologies at an advanced level. These certifications delineate a clear career trajectory for IT professionals eager to refine their expertise and progress in the domains of virtualization and cloud computing. They offer a structured path for career development within the field, showcasing an individual's proficiency in implementing and administering advanced virtualization solutions.

In conclusion, the VCP6-DCV certification is a pivotal asset for IT professionals seeking to showcase their proficiency in leveraging vSphere. This certification offers a thorough evaluation of an individual's knowledge and skills, providing an effective means to remain current with the latest advancements in the dynamic field of virtualization and cloud computing. It stands as a valuable credential attesting to an individual's expertise in deploying and managing vSphere environments.

2.3.12. VMware

VMware is a prominent force in the realm of virtualization and cloud computing technologies. The array of certifications they offer are meticulously designed to gauge an individual's proficiency in leveraging VMware technologies. These certifications serve as a structured career trajectory for IT professionals aspiring to enhance their expertise and progress within the dynamic domains of virtualization and cloud computing. They provide a clear pathway for career development, affirming an individual's competence in deploying and managing virtualized environments effectively.

One of the most esteemed VMware certifications is the VMware Certified Professional (VCP) program. Tailored for IT professionals eager to showcase their proficiency in utilizing VMware vSphere, a pivotal virtualization platform for data center management, this program attests to an individual's expertise in deploying and managing virtualized environments. It stands as a

prominent certification in the realm of virtualization and is widely recognized in the IT industry (Perry et al., 2010).

To become certified, individuals must pass a certification exam that covers the design and implementation of vSphere technologies. The exam is designed to assess a candidate's knowledge of vSphere and their ability to effectively use these technologies in real-world scenarios.

The VCP certification holds significant value for IT professionals looking to validate their expertise in the swiftly evolving domains of virtualization and cloud computing. Achieving this certification attests to an individual's profound understanding of vSphere and their capability to effectively leverage it to meet organizational requirements. It stands as a powerful indicator of an individual's proficiency in deploying and managing virtualized environments.

Beyond the VCP program, VMware extends a range of certifications crafted to evaluate an individual's proficiency in deploying and managing VMware technologies at an advanced level. These certifications furnish a structured pathway for career development within the domains of virtualization and cloud computing. They offer IT professionals a means to refine their skills and progress in their careers, affirming their expertise in implementing and administering advanced virtualization solutions.

To sum up, VMware certifications stand as pivotal assets for IT professionals seeking to showcase their proficiency in leveraging VMware technologies. These certifications offer a thorough evaluation of an individual's knowledge and skills, providing an effective means to remain current with the latest advancements in the dynamic fields of virtualization and cloud computing. They serve as valuable credentials attesting to an individual's expertise in deploying and managing virtualized environments effectively.

2.3.13.ITIL

ITIL, which stands for Information Technology Infrastructure Library, is a globally acknowledged framework for IT service management. The ITIL certification program is structured to evaluate an individual's comprehension of the ITIL framework and their capacity to implement it in practical, real-world situations (Soomro & Hesson, 2012).

ITIL offers a methodical approach to IT service management, widely adopted by organizations globally to enhance the quality and efficiency of their IT services. This framework encompasses a spectrum of best practices, encompassing service strategy, service design, service transition, service operation, and continual service improvement. By adhering to these practices, organizations can streamline their IT operations and deliver services that align with business objectives and customer needs.

The ITIL certification program is based on the ITIL framework and is designed to help individuals demonstrate their expertise in using the framework to improve the quality of their IT services (Bentley, 2006). The certification program is structured into several levels, starting with the ITIL Foundation level and progressing to the ITIL Expert level (Kaiser & Kaiser, 2021).

To attain certification, individuals are required to successfully pass a certification exam that delves into the fundamental concepts and best practices encapsulated within the ITIL framework. This examination is crafted to evaluate a candidate's proficiency in the framework and their aptitude for its practical application in real-world situations. It serves as a comprehensive assessment of the candidate's grasp of ITIL principles.

The ITIL certification stands as a crucial asset for IT professionals aiming to showcase their proficiency in IT service management, particularly in a field marked by swift evolution. It attests that individuals possess an in-depth comprehension of the ITIL framework and can adeptly leverage it to enhance the quality of their IT services. This certification serves as a powerful indicator of an individual's expertise in the dynamic landscape of IT service management.

In summary, the ITIL certification proves invaluable for IT professionals seeking to showcase their proficiency in IT service management. This certification offers a thorough evaluation of an individual's knowledge and skills, serving as an effective means to remain current with the latest advancements in this dynamic field. It stands as a testament to an individual's expertise in managing IT services effectively.

2.3.14. Certified in the Governance of Enterprise IT (CGEIT)

The Certified in the Governance of Enterprise IT (CGEIT) certification is a globally recognized certification program for IT professionals who are interested in demonstrating their expertise in IT governance. IT governance is the process of establishing policies, standards, and procedures for the effective management of IT resources and services (Iliescu, 2010).

The CGEIT certification program is designed to assess an individual's knowledge of IT governance best practices and their ability to apply these practices in real-world scenarios. To become certified, individuals must pass a certification exam that covers the key concepts and best practices of IT governance (De Haes, 2013).

The CGEIT certification holds significant importance for IT professionals looking to highlight their proficiency in IT governance, particularly in a swiftly evolving field. Achieving this certification signifies a profound comprehension of best practices in IT governance and the ability to implement them to enhance the quality and efficiency of IT services. It stands as a potent credential attesting to an individual's expertise in this critical aspect of IT management.

In addition to the certification exam, individuals must also have a minimum of five years of experience working in the field of IT governance. This requirement helps to ensure that individuals who earn the CGEIT certification have a broad and deep understanding of IT governance and its impact on organizations.

In conclusion, the CGEIT certification is a valuable tool for IT professionals who are interested in demonstrating their expertise in IT governance. The certification provides a comprehensive assessment of an individual's knowledge and skills, and is a great way for individuals to stay up-to-date with the latest developments in this field. The certification's emphasis on practical experience also helps to ensure that individuals who earn the CGEIT certification have a well-rounded understanding of IT governance and its impact on organizations.

2.3.15. Certified Information Systems Auditor (CISA)

The Certified Information Systems Auditor (CISA) certification is an internationally acknowledged program for information technology (IT) professionals aiming to showcase their proficiency in IT auditing, control, and security (Cannon, 2011).

The CISA certification program is structured to evaluate an individual's grasp of IT auditing best practices and their proficiency in applying them in practical, real-world situations. To achieve certification, individuals are required to successfully pass a comprehensive examination that delves into the essential concepts and top-tier practices within the realm of IT auditing. This certification serves as a robust testament to an individual's competence in safeguarding and managing information systems.

The CISA certification holds significant value for IT professionals looking to underscore their expertise in IT auditing and control, particularly in an industry marked by rapid advancements. This certification attests that individuals possess a profound grasp of best practices in IT auditing and can effectively apply them to enhance the quality and efficiency of IT systems and processes. It stands as a powerful indicator of an individual's proficiency in this critical aspect of IT management (Gregg & Johnson, 2017).

In addition to passing the certification exam, candidates are mandated to possess at least five years of professional experience within the field of IT auditing. This prerequisite serves as a safeguard to guarantee that individuals who attain the CISA certification possess a comprehensive and profound comprehension of IT auditing and its pivotal role in organizational operations. It underscores the significance of practical expertise in this critical domain.

To sum up, the CISA certification stands as a pivotal asset for IT professionals seeking to showcase their proficiency in IT auditing, control, and security. This certification offers a thorough evaluation of an individual's knowledge and skills, serving as an effective means to remain current with the latest advancements in this dynamic field. Moreover, the emphasis on practical experience ensures that CISA-certified individuals possess a comprehensive understanding of IT auditing and its organizational impact. It is a credential of substantial value in the realm of IT management.

2.3.16. Certified Information Security Manager (CISM)

The Certified Information Security Manager (CISM) certification is a globally recognized certification program for information security professionals who are interested in demonstrating their expertise in managing, designing, and overseeing an organization's information security program (Peltier & Peltier, 2016).

The CISM certification program is structured to evaluate an individual's comprehension of best practices in information security management and their capacity to effectively apply them in practical, real-world situations. To achieve certification, individuals must successfully pass an examination that delves into the essential concepts and top-tier practices within information security management. This certification attests to an individual's proficiency in safeguarding information assets and aligning security initiatives with business objectives.

The CISM certification holds significant importance for information security professionals aiming to highlight their proficiency in managing and overseeing information security programs, especially in an industry characterized by swift evolution. This certification signifies that individuals possess a profound comprehension of best practices in information security management and can effectively apply them to enhance the quality and efficiency of their organization's security initiatives. It stands as a powerful indicator of an individual's expertise in this crucial facet of information security (Messmer, 2004).

In addition to the certification exam, individuals must also have a minimum of five years of experience working in the field of information security management. This requirement helps to ensure that individuals who earn the CISM certification have a broad and deep understanding of information security management and its impact on organizations.

In conclusion, the CISM certification is a valuable tool for information security professionals who are interested in demonstrating their expertise in managing and overseeing information security programs. The certification provides a comprehensive assessment of an individual's knowledge and skills, and is a great way for individuals to stay up-to-date with the latest developments in this field. The certification's emphasis on practical experience also helps to ensure that individuals who earn the CISM certification have a well-rounded understanding of information security management and its impact on organizations.

2.3.17. (ISC)² Systems Security Certified Practitioner (SSCP)

The (ISC)² Systems Security Certified Practitioner (SSCP) certification is a globally recognized certification program for information security professionals who are interested in demonstrating

their expertise in the practical application of information security concepts and practices (Murphy, 2015).

The SSCP certification program is meticulously crafted to evaluate an individual's proficiency in information security best practices and their capability to apply them in practical, real-world situations. Attaining certification requires successfully passing an examination that delves into the fundamental concepts and top-tier practices within the realm of information security. This certification serves as a robust testament to an individual's competence in safeguarding and managing information assets (Contesti et al., 2007).

The SSCP certification holds significant importance for information security professionals eager to showcase their proficiency in the practical implementation of information security concepts and practices, particularly in a field marked by rapid evolution. This certification attests that individuals possess a profound understanding of information security best practices and are adept in applying them to enhance the security of their organization's information systems. It stands as a powerful indicator of an individual's expertise in safeguarding critical information assets.

In addition to passing the certification exam, candidates must also possess a minimum of one year of professional experience within the field of information security. This prerequisite serves as a safeguard to guarantee that individuals who attain the SSCP certification possess not only theoretical knowledge but also practical expertise in information security and its pivotal role in organizational operations. It underscores the significance of hands-on experience in this critical domain.

To sum up, the SSCP certification proves instrumental for information security professionals seeking to showcase their proficiency in the practical implementation of information security concepts and practices. This certification offers a thorough evaluation of an individual's knowledge and skills, providing an effective means to remain current with the latest advancements in this dynamic field. Moreover, the emphasis on practical experience ensures that SSCP-certified individuals possess a comprehensive understanding of information security and its organizational impact. It is a credential of substantial value in the realm of information security.

2.3.18. Certified Fiber Optic Technician (CFOT)

The Certified Fiber Optic Technician (CFOT) certification is a widely recognized certification program in the field of fiber optics technology. This certification is offered by the Fiber Optic Association (FOA), an international non-profit organization that is dedicated to promoting fiber optic education and certification. The CFOT certification is designed to demonstrate the competency of individuals in the installation, testing, and maintenance of fiber optic networks (Woodward & Husson, 2006).

The CFOT certification requires passing a written exam, which covers topics such as basic fiber optics principles, installation practices, safety, testing and maintenance procedures. The written exam tests the candidate's knowledge of the concepts and practical applications of fiber optic technology. The certification is valid for three years, after which the individual must re-certify to maintain their CFOT status.

The CFOT certification is widely accepted by employers in the fiber optic industry as a demonstration of technical competence. The certification provides assurance to employers that the certified technician has the necessary knowledge and skills to install and maintain fiber optic networks. The CFOT certification is also beneficial for technicians as it demonstrates their commitment to their profession and helps to increase their credibility in the industry (Woodward & Husson, 2006).

In conclusion, the CFOT certification is a widely recognized and valuable certification for fiber optic technicians. The certification provides assurance to employers of the technician's competency, and it helps technicians to increase their credibility in the industry. The CFOT certification is also beneficial for the fiber optic industry as a whole as it helps to ensure that fiber optic networks are installed and maintained to the highest standards of quality and safety.

2.3.19. Certified Fiber Optic Specialist (CFOS)

The Certified Fiber Optic Specialist (CFOS)⁸ certification is a professional certification program in the field of fiber optics technology. The CFOS certification is offered by the Fiber Optic

⁸ <https://www.thefoa.org/adv-cert.htm>

Association (FOA), an international non-profit organization that is dedicated to promoting fiber optic education and certification. The CFOS certification is designed to demonstrate the competency of individuals in the design, installation, and maintenance of fiber optic networks.

The CFOS certification requires passing a written exam, which covers topics such as fiber optic components, systems design, installation practices, testing, and maintenance procedures. The written exam tests the candidate's knowledge of the concepts and practical applications of fiber optic technology. The certification is valid for three years, after which the individual must re-certify to maintain their CFOS status.

The CFOS certification is widely accepted by employers in the fiber optic industry as a demonstration of technical competence. The certification provides assurance to employers that the certified specialist has the necessary knowledge and skills to design, install, and maintain fiber optic networks. The CFOS certification is also beneficial for specialists as it demonstrates their commitment to their profession and helps to increase their credibility in the industry.

In conclusion, the CFOS certification is a valuable certification for fiber optic specialists. The certification provides assurance to employers of the specialist's competency, and it helps specialists to increase their credibility in the industry. The CFOS certification is also beneficial for the fiber optic industry as a whole as it helps to ensure that fiber optic networks are designed, installed, and maintained to the highest standards of quality and safety.

2.3.20. Certified Network Defender (CND)

The Certified Network Defender (CND) certification is a distinguished professional certification program specializing in network security. Administered by the Electronic Crimes Task Force (ECTF) under the purview of the International Association of Computer Security Professionals (IACSP), this certification is meticulously crafted to showcase individuals' proficiency in safeguarding computer networks. It stands as a testament to an individual's competency in network defense.

Attaining the CND certification entails successfully passing a comprehensive written exam. This examination encompasses a spectrum of critical topics including network security technologies,

security operations, threat and vulnerability management, incident response, and cryptography. It serves as a rigorous assessment of the candidate's comprehension and practical application of network security concepts. The CND certification remains valid for a duration of three years, after which re-certification is required to sustain the individual's CND status. This process ensures that certified professionals stay current with evolving network security practices.

The CND certification is widely recognized by employers in the network security industry as a demonstration of technical competence. The certification provides assurance to employers that the certified defender has the necessary knowledge and skills to defend computer networks against security threats. The CND certification is also beneficial for network security professionals as it demonstrates their commitment to their profession and helps to increase their credibility in the industry.

In conclusion, the CND certification is a valuable certification for network security professionals. The certification provides assurance to employers of the defender's competency, and it helps network security professionals to increase their credibility in the industry. The CND certification is also beneficial for the network security industry as a whole as it helps to ensure that computer networks are defendable against security threats.

Online or in-person bootcamps, or classes from universities or colleges are also a good way to get training in computer network technologies. A degree in computer science or a related field can also be helpful for pursuing a career in network technology.

Additionally, hands-on experience through internships or real-world projects is an important aspect of training in computer network technologies, as it provides an opportunity to apply the concepts and skills learned in a practical setting (Chang, 2004).

Education is also important for staying current in the field of computer network technologies, as new technologies and best practices are constantly emerging. This can include taking additional courses or certifications, attending industry conferences and events, or staying up-to-date through reading trade publications or following thought leaders in the field.

It's also important to have a good understanding of the different types of networks and the different protocols and technologies used in each type. For example, understanding the differences between LANs, WANs, and WLANs, as well as the protocols used to connect and secure them, is important for designing and troubleshooting networks.

Additionally, understanding the different types of routing and switching technologies, such as static routing and dynamic routing, is crucial for configuring and maintaining networks.

In summary, training in computer network technologies can involve learning the concepts, technologies, and protocols used in designing, implementing, and maintaining computer networks, through certifications, online courses, university degrees, internships or real-world projects, and staying up-to-date through continuing education.

2.4. Content of Training in Computer Network Technologies

One of the main topics covered by educational applications in computer network technologies is network fundamentals. This includes the basics of computer networks, such as the OSI and TCP/IP models, network topologies, and protocols. Understanding the fundamental concepts and technologies of computer networks is essential for working with more advanced topics, such as routing and switching, wireless networks, and network security (Spirin et al., 2019).

Routing and switching is another important topic covered by educational applications in computer network technologies. This includes the concepts and technologies used to create and manage computer networks, such as routing protocols, VLANs, and network security. Understanding routing and switching is essential for configuring and maintaining computer networks. It also helps students to learn how to troubleshoot network issues and improve network performance (Dinita et al., 2012).

Wireless networks are another important topic covered by educational applications in computer network technologies. This includes the concepts and technologies used to create and manage wireless networks, such as Wi-Fi, Bluetooth, and cellular networks. Understanding wireless networks is essential for working with mobile devices and IoT (Internet of Things) networks. It

also helps students to learn how to secure wireless networks and improve wireless network performance (Spirin et al., 2019).

Network security is another important topic covered by educational applications in computer network technologies. This includes the concepts and technologies used to secure computer networks, such as firewalls, intrusion detection and prevention systems, and encryption (Yuan et al., 2010). Understanding network security is essential for protecting computer networks from cyber threats and data breaches. It also helps students to learn how to implement security measures and comply with security regulations (Irvine & Thompson, 2003).

Cloud computing is another topic that is covered by educational applications in computer network technologies. This includes the concepts and technologies used to create and manage cloud-based networks, such as Software-Defined Networking (SDN), Network Function Virtualization (NFV), and Cloud-based Security (Moravčík et al., 2017).

Based on the previous research, it is possible to define 10 computer network subjects to categorize the certifications that each company provides:

1. Network Architecture: This subject covers the fundamental concepts and principles of network architecture, such as types of networks, network topologies, and network protocols. It also includes an introduction to the OSI and TCP/IP models, which are widely used to understand how data is transmitted over networks (Sunshine, 2013).
2. Internet Protocols: This subject covers the various internet protocols that are used to transmit data over networks, such as TCP, UDP, and ICMP. It also covers other important protocols such as DHCP, DNS, and FTP, which are used to manage and configure networks (Sunshine, 2013).
3. Network Security: This subject covers the various security threats that can affect networks, and the methods and technologies used to protect networks from those threats. This includes topics such as firewalls, intrusion detection systems, and encryption (Kizza, 2005).

4. **Network Troubleshooting:** This subject covers the methods and tools used to troubleshoot and diagnose network problems. It includes topics such as network monitoring, packet capturing, and protocol analysis (Ozturk, 2011).
5. **Routing and Switching:** This subject covers the various routing and switching technologies that are used to connect and manage networks, such as static routing, dynamic routing, and VLANs. It also covers routing protocols, such as OSPF and BGP, and how they are used to connect and manage networks (Pióro & Medhi, 2004).
6. **Wireless Networking:** This subject covers the concepts and technologies used in wireless networks, such as Wi-Fi, Bluetooth, and cellular networks. It also covers the security concerns and best practices for wireless networks (Sarangapani, 2017).
7. **Cloud Computing:** This subject covers the fundamentals of cloud computing, including how it works, the different types of cloud services, and the benefits and challenges of using cloud computing (Goyal & Dadizadeh, 2009).
8. **Virtual Private Networks (VPNs) and Software-defined networks (SDN):** This subject covers the concepts and technologies used to improve the security and flexibility of networks. It includes topics such as VPN protocols, VPN deployment, and the benefits and challenges of using VPNs and SDN(Feng, 2014; Rana et al., 2019).
9. **Network Management:** This subject covers the tools and techniques used to manage and maintain networks. It includes topics such as network monitoring, troubleshooting, and performance management (Lee et al., 2014).
10. **Industry Standards and Best Practices:** This subject covers the industry standards and best practices that are used in networking, such as IEEE and ISO standards, and the best practices for network design and deployment (Falk, 2005; Sheng et al., 2013).

The following table categorizes the most common certifications in each subject that was previously defined:

	Cisco Systems	Juniper Networks	CompTIA	Microsoft	Other
Network Architecture	CCNA, CCNP, CCIE	JNCIA, JNCIS, JNCIE	-	MCSA, MCSE, MCITP	AWS Certified Solutions Architect, CISSP
Internet Protocols	CCNA, CCNP, CCIE	JNCIA, JNCIS, JNCIE	Network+	MCSA, MCSE, MCITP	LPIC-1, LPIC-2
Network Security	CCNA Security, CCNP Security, CCIE Security	JNCIA-SEC, JNCIS-SEC, JNCIE-SEC	Security+	-	CISSP, CEH, CIPP, SSCP
Network Troubleshooting	CCNA	JNCIA	Network+	Azure Administrator Associate	AWS Certified Solutions Architect – Associate
Routing and Switching	CCNA, CCNP	JNCIA, JNCIP	-	Azure Administrator Associate	-
Wireless Networking	CCNA Wireless	-	Network+	-	CWNA, CWTS, CWAP
Cloud Computing	-	-	-	Azure Administrator Associate	AWS Certified Solutions Architect – Associate, Red Hat Certified Engineer in Red Hat OpenStack, Google Certified Professional – Cloud Architect, VCP-CMA
VPNs and SDN	CCNA Security, CCNP Security, CCIE Security	JNCIA-SEC, JNCIS-SEC, JNCIE-SEC	Security+	-	NSE, PCNSA, PCNSE
Network Management	CCNA, CCNP, CCIE	JNCIA, JNCIS, JNCIE	Network+	MCSE	CNE
Industry Standards and Best Practices	-	-	A+, Network+, Security+, Server+	-	CISA, CISM, CRISC, GIAC, CISSP, SSCP, CSSLP, HCISPP

Table 1: Certifications based on companies and subjects

It's also important to note that many training programs in computer network technologies include certification exams that are designed to test the knowledge and skills of the students. These certifications, such as CCNA, CompTIA Network+, and others, are widely recognized and respected in the industry, and can open up a wide range of career opportunities for those who earn them.

In summary, training in computer network technologies indeed encompasses a broad spectrum of crucial subjects, ranging from network architecture to security, troubleshooting, and much more. This training can be delivered through various methods, including classroom-based instruction, online courses, self-study, and hands-on exercises. This well-rounded approach ensures that individuals gain a comprehensive understanding of the intricacies involved in designing, implementing, and maintaining computer networks.

Training in computer network technologies offers a thorough grasp of the diverse concepts, technologies, and protocols employed in networking. This equips professionals with the expertise needed to craft, execute, and manage computer networks effectively. Moreover, it ensures they remain abreast of the newest technologies and optimal approaches in the field, while also unveiling a broad spectrum of career prospects. The certifications integrated into these training programs, like CCNA and CompTIA Network+, hold substantial value in the networking domain, being widely acknowledged and esteemed within the industry.

It's also worth mentioning that training in computer network technologies can be beneficial for professionals working in other fields as well, as many industries rely on computer networks to share resources and information. This includes fields such as technology, finance, healthcare, and government (Alemdar & Ersoy, 2010). Even small businesses, non-profits, and individuals benefit from computer network technologies to manage their operations and communicate with their customers and partners. Therefore, having a solid understanding of computer network technologies can be a valuable asset for professionals in any field.

Another aspect to consider is that computer network technologies are constantly evolving, new protocols, standards and technologies are emerging, thus, ongoing training is crucial to keep up

with the changes and to make sure that professionals are using the most current and efficient technologies available. This also includes staying up to date with new security threats and best practices to protect networks from those threats.

In summary, training in computer network technologies stands as a crucial component of a career in networking, and proves equally valuable for professionals in various other sectors reliant on computer networks. It furnishes the expertise needed for network design, implementation, and maintenance, ensuring professionals remain abreast of cutting-edge technologies and best practices. This, in turn, leads to a wealth of career opportunities. Additionally, certifications such as CCNA and CompTIA Network+, integrated into these programs, hold significant worth in the networking realm. Given the continuous evolution of the field, ongoing training is imperative to ensure professionals are utilizing the most current and effective technologies available, enabling them to adapt to industry changes seamlessly.

2.5. Certification Frameworks and Subject Categorization in Computer Networking

In Chapter 2, we explored the training programs available in computer network technologies, including various certifications and their importance. The certifications discussed ranged from basic network administration to advanced topics such as information security and cloud computing. Additionally, the content of these training programs was also discussed, emphasizing the need for hands-on practical experience. In Chapter 2.5, we also discussed certifications available for educational applications in computer network technologies.

As we transition to Chapter 3, we will delve into the review of educational applications in computer network technologies. We will examine the different types of educational tools available to help individuals learn about computer networks, including network simulators, network emulators, and online learning platforms. The aim of this review is to provide a comprehensive overview of the available educational tools and to determine their effectiveness in facilitating learning and training in computer network technologies. This information will provide the basis for the implementation of our application to support tests in computer network technologies.

3. CHAPTER 2nd: Review of Educational Applications in Computer Network Technologies

A review of educational applications in computer network technologies would involve researching and analyzing the existing literature on the use of educational applications to teach and learn about computer networks. The review would likely focus on studies and articles that have examined the effectiveness of different educational applications in teaching computer network technologies, as well as the challenges and limitations of using these applications in an educational setting (Matthews, 2005).

Several pieces of literature indicate that educational tools like network simulators prove to be an efficient method for instructing computer network technologies. These simulators enable students to explore diverse network setups and protocols in a simulated setting, thereby enhancing their comprehension of the subject matter. Moreover, research has demonstrated that the incorporation of educational applications can elevate student participation and enthusiasm in studying computer networks (Prvan & Ožegović, 2020).

Other studies have found that educational applications can be a valuable tool for teaching hands-on skills in computer network technologies. For example, using network emulators, students can practice configuring, troubleshooting and monitoring network devices, which can be beneficial for preparing them for real-world work (Janitor et al., 2010).

However, the literature also highlights some challenges and limitations of using educational applications in teaching computer network technologies. One of the main challenges is that many educational applications are not able to fully replicate the complexity and diversity of real-world networks (Nelson & Ng 2000). Additionally, educational applications can be expensive, and not all educational institutions can afford them, which can be a barrier for some students.

In summary, a review of educational applications in computer network technologies would likely find that educational applications, such as network simulators, can be an effective tool for teaching and learning about computer networks. They can provide students with a hands-on experience, improve student engagement and motivation, and help to deepen their understanding of the material. However, the literature also highlights some challenges and limitations of using

educational applications in teaching computer network technologies, such as cost, complexity, and the inability to fully replicate real-world networks.

3.1. Network simulators

Network simulators, such as Cisco Packet Tracer (Rashid et al., 2019), GNS3 (Gil et al., 2014) and NS-2 (Jin et al., 2009), are widely used in teaching computer network technologies. These simulators allow students to experiment with different network configurations and protocols in a virtual environment, which can help to deepen their understanding of the material. For example, a study published in the *Journal of Computer Science Education* found that the use of the Cisco Packet Tracer network simulator improved students' understanding of networking concepts and enhanced their problem-solving skills (Javid, 2014; Zhang et al., 2012).

Network simulators are widely used in teaching computer network technologies as they provide an effective tool for students to experiment with different network configurations and protocols in a virtual environment (Gurgel et al., 2013). These simulators allow students to simulate various network scenarios, including complex network topologies and protocols, without the need for expensive hardware. This can help to deepen their understanding of the material and improve their problem-solving skills (Wangchuk, 2018).

One of the main advantages of network simulators is that they allow students to practice configuring, troubleshooting and monitoring network devices in a safe and controlled environment. This can be beneficial for preparing them for real-world work, as students can make mistakes and learn from them without affecting a real network (Segeč et al., 2015). Additionally, network simulators provide students with a visual representation of the network, which can be helpful for understanding the different components and how they interact with each other (Sllame & Jafaray, 2013).

Another advantage of network simulators is that they can be used to simulate real-world scenarios that may be difficult or impossible to replicate in a classroom setting. For example, students can simulate a network outage or a security breach, and learn how to troubleshoot and resolve these issues (Qun & Jun, 2008).

However, there are also limitations to using network simulators in teaching computer network technologies. One of the main limitations is that network simulators may not fully replicate the complexity and diversity of real-world networks. Additionally, network simulators can be expensive, and not all educational institutions can afford them, which can be a barrier for some students.

In conclusion, network simulators are widely used in teaching computer network technologies as they provide an effective tool for students to experiment with different network configurations and protocols in a virtual environment. They offer many advantages such as allowing students to practice configuring, troubleshooting and monitoring network devices in a safe and controlled environment, providing students with a visual representation of the network, and simulating real-world scenarios that may be difficult or impossible to replicate in a classroom setting. However, there are also limitations to using network simulators such as not fully replicating the complexity and diversity of real-world networks, and being expensive which may limit accessibility for some students (Nayak et al., 2016).

3.2. Network emulators

Network emulators, such as VMW⁹ and VirtualBox¹⁰, are commonly used to teach hands-on skills in computer network technologies. These emulators allow students to practice configuring, troubleshooting, and monitoring network devices in a virtual environment, which can be beneficial for preparing them for real-world work. A study published in the Journal of Computer Science and Technology found that the use of network emulators improved students' hands-on skills and increased their confidence in working with network devices (Huang et al., 2014; Goldweber & Davoli, 2008).

Network emulators are commonly used in teaching computer network technologies as they provide a valuable tool for students to learn hands-on skills in a virtual environment. These emulators allow students to practice configuring, troubleshooting, and monitoring network devices, without the

⁹ <https://www.vmware.com/>

¹⁰ <https://www.virtualbox.org/>

need for expensive hardware. This can be beneficial for preparing them for real-world work (Pizzonia & Rimondini, 2016).

Network emulators offer a significant advantage by providing students with a hands-on learning experience within a secure and supervised setting. This proves particularly advantageous for students without access to actual networks or costly equipment. Furthermore, these emulators furnish students with a virtual environment that closely replicates real-world networks, aiding in the comprehension of how various components and protocols interact (Sierszeń et al., 2017).

Network emulators offer another notable advantage in their capacity to replicate real-world scenarios, some of which may pose challenges or even be impossible to recreate in a traditional classroom environment. For instance, students can simulate scenarios like network outages or security breaches, gaining valuable experience in troubleshooting and resolution techniques (Ozturk, 2011).

However, there are also limitations to using network emulators in teaching computer network technologies. One of the main limitations is that network emulators may not fully replicate the complexity and diversity of real-world networks (Nogueira & Salvador, 2014). Additionally, network emulators can be resource-intensive and require powerful computers to run, which can be a barrier for some students.

In summary, network emulators are widely employed in instructing computer network technologies, offering students a valuable opportunity to acquire hands-on skills in a virtual setting. They bring several advantages, including the ability to learn in a secure and supervised environment, closely mimicking real-world networks, and simulating scenarios that may be challenging to replicate in a traditional classroom setting.

However, like any other technology, there are limitations to using network emulators, such as not fully replicating the complexity and diversity of real-world networks, and requiring powerful computers to run, which can be a barrier for some students. It's also important to note that while network emulators are a useful tool for teaching hands-on skills, they should be used in conjunction with other teaching methods such as lectures, discussions, and hands-on labs with real equipment. This can provide students with a well-rounded education, preparing them for the real-world

scenarios. Additionally, network emulators can also be used for research and experimentation purposes, for example, testing new protocols, validating network designs and simulating new network scenarios.

Overall, network emulators can be a valuable tool for teaching computer network technologies, but it's important to consider the limitations and use them as a supplement to other teaching methods. They allow students to learn hands-on skills in a virtual environment, which can be beneficial for preparing them for real-world work, but should not be considered as a replacement for real-world experience and the use of real equipment (Chou et al., 2016).

Another important aspect to consider is that network emulators should be accompanied by appropriate training and guidance for the instructors and students. This includes providing adequate resources, such as detailed user manuals, tutorials, and best practices. The instructor should be familiar with the specific emulator software and have experience using it to teach. This will ensure that students can make the most of the emulator and that the instructor can answer any questions that may arise during the class. Furthermore, the instructor should be able to use the emulator to demonstrate different network scenarios, troubleshoot network issues, and provide examples of best practices (Chaves et al., 2021).

In summary, network emulators are a valuable tool for teaching computer network technologies, but they should be used in conjunction with other teaching methods such as lectures, discussions, and hands-on labs with real equipment. They allow students to learn hands-on skills in a virtual environment, which can be beneficial for preparing them for real-world work, but should not be considered as a replacement for real-world experience and the use of real equipment. Additionally, network emulators can also be used for research and experimentation purposes. Lastly, network emulators should be accompanied by appropriate training and guidance for the instructors and students, including providing adequate resources and ensuring that the instructor is familiar with the specific emulator software and has experience using it to teach.

3.3. Online learning platforms

Online learning platforms (Pappano, 2012), including well-known platforms like Coursera, Udemy, and edX, provide an extensive array of courses and programs covering computer network

technologies. They afford students the flexibility to learn at their own speed and according to their own timetable, catering especially to those who may face challenges attending conventional classroom-based instruction (Yurchenko et al., 2021).

Online learning platforms, exemplified by Coursera, Udemy, and edX, have witnessed a surge in popularity as avenues for instructing computer network technologies. These platforms provide a diverse array of courses and programs in this field, affording students the flexibility to learn autonomously and according to their individual schedules (Verdú et al., 2017).

One of the main advantages of online learning platforms is that they provide students with flexibility and convenience (Pappano, 2012). Students can access the course materials, lectures, and assignments from anywhere with an internet connection, and can learn at their own pace. This can be beneficial for students who may have busy schedules, or for those who live in areas where there is limited access to traditional classroom-based instruction (Vakaliuk et al., 2020).

Another advantage of online learning platforms is that they can provide students with a wide range of resources, including video lectures, quizzes, and hands-on exercises. These resources can be used to supplement traditional classroom-based instruction and can provide students with a more well-rounded education (Korableva et al., 2019). Additionally, online learning platforms can connect students with a global community of learners, which can be beneficial for networking and peer-to-peer learning.

However, there are also limitations to using online learning platforms in teaching computer network technologies (Coti et al., 2015). One of the main limitations is that online learning can be less interactive than traditional classroom-based instruction. Additionally, online learning platforms can be less effective at providing hands-on experience, which is crucial in computer network technologies.

In conclusion, online learning platforms, such as Coursera, Udemy, and edX, have become increasingly popular as a way to teach computer network technologies. They offer flexibility and convenience, a wide range of resources, and the ability to connect with a global community of learners. However, they also have limitations such as less interactivity than traditional classroom-based instruction, and less effective at providing hands-on experience. Therefore, it's important to

consider using online learning platforms as a supplement to traditional classroom-based instruction, rather than a replacement. This can provide students with a more well-rounded education and access to a wide range of resources and hands-on exercises.

3.3.1. The Online Platform of Oracle Academy

Oracle Academy is a global education program created by Oracle Corporation to provide students and educators with access to technology resources, tools, and curriculum to advance computer science education. The online platform of Oracle Academy provides students with a wealth of resources to help them learn about computer network technologies. One of the key features of the Oracle Academy online platform is its courses and curriculum (Gooris & Mateo, 2016). The courses offered through the platform cover a wide range of topics related to computer science and information technology, including computer networks. These courses are designed to be engaging and interactive, providing students with hands-on experience and practical knowledge they can apply in real-world situations. Another important aspect of the Oracle Academy online platform is its community of educators and students (Stalvey et al., 2012). Through the platform, educators and students can connect with each other and engage in discussions about various topics related to computer science and information technology. This community provides students with access to a wealth of knowledge and resources and provides educators with the opportunity to collaborate and share best practices (Urem et al., 2018).

In terms of the role of the Oracle Academy online platform in education in computer network technologies, it plays a significant role in helping students and educators learn about this important field. The platform provides students with access to high-quality, relevant content that is designed to help them understand the fundamental concepts of computer networks (Stalvey et al., 2012). This content is backed by the expertise and resources of the Oracle Corporation, ensuring that it is current, accurate, and relevant. Furthermore, the online platform provides students with hands-on experience and practical knowledge through its interactive courses and online lab environments. This hands-on experience is critical in helping students understand the real-world applications of computer networks and how they can be used to solve real-world problems (Urem et al., 2020). In conclusion, the Oracle Academy online platform is an important resource for students and educators looking to learn about computer network technologies. The platform provides high-

quality, relevant content, hands-on experience, and access to a community of experts and peers, making it an essential tool for anyone looking to advance their knowledge in this field.

3.3.2. The Online Platform of Coursera

Coursera is a leading online learning platform that offers a wide range of courses in computer network technologies, as well as other subjects. The platform provides students with access to high-quality, relevant content and expert instructors, making it an important resource for anyone looking to advance their knowledge in computer network technologies. One of the key features of the Coursera platform is its courses and curriculum (Young, 2012). Coursera offers a variety of courses in computer network technologies, including introductory and advanced level courses. These courses are designed to provide students with a comprehensive understanding of the subject, covering topics such as computer networking fundamentals, data communication, and network security. Another important aspect of the Coursera platform is its instructors. Courses on the platform are taught by experts from top universities and institutions, ensuring that the content is current, accurate, and relevant. These instructors provide students with in-depth explanations and hands-on examples, making it easier to understand the complex concepts of computer network technologies (Ayoub et al., 2020).

In terms of the role of the Coursera platform in education in computer network technologies, it plays a significant role in helping students and professionals learn about this important field. The platform provides students with access to high-quality, relevant content that is designed to help them understand the fundamental concepts of computer networks. This content is backed by the expertise of the instructors, ensuring that it is current, accurate, and relevant. Furthermore, the Coursera platform provides students with flexible learning options, allowing them to study at their own pace and on their own schedule. This makes it an ideal choice for students who are unable to attend traditional brick-and-mortar classes, or who are looking for a more flexible learning experience (Shafiq et al., 2017). In conclusion, the Coursera platform is an important resource for students and professionals looking to learn about computer network technologies. The platform provides high-quality, relevant content, expert instructors, and flexible learning options, making it an essential tool for anyone looking to advance their knowledge in this field (Silvia, 2015).

3.3.3. LinkedIn Learning

LinkedIn Learning stands out as an online educational platform offering a diverse selection of courses spanning computer network technologies and various other subjects. Tailored to aid professionals in skill acquisition and career advancement, it emerges as a pivotal resource for those seeking expertise in computer network technologies. A distinctive hallmark of LinkedIn Learning lies in its strong emphasis on career progression (Kennedy, 2019). The platform equips students with courses and materials strategically crafted to bolster their competence, essential for excelling in their respective professions. This focus on career growth assumes particular significance in the dynamic realm of computer network technologies, where staying abreast of developments is paramount for competitiveness due to the ever-changing landscape. Another noteworthy facet of LinkedIn Learning is its faculty. Courses are delivered by accomplished experts hailing from esteemed universities and institutions, ensuring the content remains contemporary, precise, and pertinent. These instructors furnish students with comprehensive elucidations and practical demonstrations, rendering the intricate facets of computer network technologies more accessible (Carson & Marshall, 2019).

LinkedIn Learning assumes a crucial role in the education of computer network technologies by empowering professionals to cultivate the essential skills and knowledge vital for success in this domain. The platform grants students access to top-tier, pertinent content meticulously designed to elucidate the foundational principles of computer networks. This educational material is bolstered by the proficiency of the instructors, guaranteeing its timeliness, precision, and relevance (Cooper & Naatus, 2014). Moreover, LinkedIn Learning extends flexible learning avenues, enabling individuals to progress at their own pace and in accordance with their unique schedules. This characteristic renders it an optimal choice for professionals unable to engage in conventional in-person classes or those seeking a more adaptable learning experience. In summation, LinkedIn Learning stands as a pivotal resource for professionals seeking to delve into the realm of computer network technologies. The platform offers high-caliber, pertinent content, seasoned instructors, and adaptable learning options, rendering it an indispensable instrument for anyone aspiring to augment their proficiency in this field and cultivate the capabilities requisite for triumph in their careers (Barbeau, 2019).

3.3.4. Open eClass

Open eClass is a free course management system that has been widely used by academic institutions and secondary schools in Greece. Since its initial release in 2003, based on the Claroline open source platform, Open eClass has undergone multiple updates and developments, becoming an autonomous platform with a wide range of features (Pliakoura et al., 2020). The platform supports thousands of e-courses and is widely used for electronic class services in Greek schools. The platform provides a communication channel and an open network of facilities to facilitate its design and development (Kartaloglou & Fyntanoglou, 2015).

The e-course is the central component of the Open eClass platform. Each course integrates a series of subsystems, including an Agenda, Documents, Announcements, Discussion Areas, Workgroups, Links, Learner Assignments, Self-Assessment Exercises, Course Description, Glossary, Electronic Book, Multimedia, Learning Line, Chat, Telecollaboration, Questionnaires, a wiki, Message Exchange Area, Scoreboard, Attendance log, and Statistics (Patsiomitou, 2015). The subsystems are designed to support the teacher in organizing and presenting educational material, as well as promoting interaction and collaboration between learners and instructors. The platform is designed to provide a flexible, modular structure that can be tailored to the needs of each course, from simple informative websites to fully dynamic training environments (Pliakoura et al., 2020).

3.3.5. Moodle

Moodle is a widely accepted and widely used platform for online education. It is a free and open-source course management software or a learning management system that supports asynchronous distance learning (Gamage et al., 2022). The platform was created in 1999 by Martin Dougiamas, who based it on the philosophy of social constructionism. With over 90 million users worldwide and available in more than 75 languages, Moodle has become the most widely accepted platform in the world. Moodle offers a wide range of tools to support learning and teaching, including resources management, communication support, teamwork promotion, assessment support, and management control (Lobach et al., 2021). The platform is not the cutting edge of innovation in education technologies, but it is constantly evolving and incorporating new features. Based on the

constructivist theory of learning, Moodle encourages students to actively engage with the educational material, develop critical thinking, and cooperate with others (Blagojević & Milošević, 2015).

The first innovative aspect of using Moodle is its epistemological differentiation in the representation of knowledge, which allows for the multiple renewal of traditional school textbook knowledge. The second innovation is institutional, as Moodle requires users to assume roles within the course and allows for role reversal between students and teachers (Lobach et al., 2021). The third innovation concerns networking, as Moodle enables students and teachers to exchange messages, share resources, and co-shape content through integrated wikis, and collaborate with other schools. A teacher can use Moodle to present lessons in an engaging manner, assign tasks to students, communicate with students, design questions, form discussion groups, add educational material, and evaluate assignments. Moodle provides a comprehensive platform for conducting online courses that supports learning and teaching through its innovative features (Gamage et al., 2022).

4. CHAPTER 3rd: From Theory to Practice

4.1 Purpose of the Application

In the realm of computer networks, a discernible void in learning tools has become evident. This thesis embarks on a pivotal mission to bridge this gap by conceiving an innovative online application. The primary purpose is to furnish students with a dynamic platform for learning and self-assessment. Simultaneously, this digital tool empowers educators to scrutinize and pinpoint the specific lacunae in their students' understanding, paving the way for more precise interventions to address these gaps. Through the seamless integration of technology and education, the envisaged application aspires to be a catalyst for enhanced learning experiences within the domain of computer networks.

Expanding on this groundwork, the envisioned online application aspires to redefine the educational landscape in computer networks. It is designed to foster a collaborative learning environment featuring multiple-choice questions. Through these assessments, students can gauge their understanding, receiving immediate feedback on correct or incorrect answers. The platform goes beyond conventional testing, incorporating a learning feature where students can prepare and study possible questions.

For educators, the application provides a comprehensive insight where they can access detailed analytics of student performance. This includes a historical overview of a student's test results, facilitating a nuanced understanding of each student's learning progression. Moreover, teachers wield the capability to craft customized tests, ensuring alignment with specific learning objectives. This dual functionality empowers educators not only to assess current knowledge gaps but also to curate assessments that dynamically adapt to the evolving needs of their students within the dynamic realm of computer networks.

4.2 Methodology

The initial phase of the application's development focused on thorough requirements gathering, entailing a comprehensive analysis of objectives, functionalities, and user expectations. This process set the stage for a clearly defined project scope, where the perspectives and insights of key

participants were methodically gathered. This collaborative approach ensured that the application would adeptly meet the distinct requirements of both computer network exam candidates and educators seeking advanced assessment tools, fostering a more inclusive and tailored development process.

Following requirements gathering, the design phase took shape, guided by the principles of creating a client-server model. On the server side, the architecture was tailored to accommodate a robust database housing a myriad of questions and answers crucial for exam preparation. Simultaneously, the client-side design focused on an intuitive and user-friendly web interface, optimizing the learning experience for students interacting with the application. This dual-pronged design approach aimed at creating a seamless and efficient system capable of delivering a comprehensive learning environment.

Implementation marked the translation of design blueprints into a functional reality. The server-side implementation involved the establishment of a resilient infrastructure to handle the extensive database. On the client-side, the web interface was brought to life, incorporating features that promoted an engaging and effective study experience. This phase encapsulated the transformation of conceptual designs into a tangible and operational application framework.

Testing, a pivotal stage in the development life cycle, encompassed a meticulous examination of each module's functionality. The modular design approach facilitated focused testing on individual components, ensuring that each module met predefined standards before integration into the final system. During this phase, robust error handling and printing mechanisms were implemented to systematically identify, address, and communicate any discrepancies. This meticulous approach not only guaranteed the application's reliability, accuracy, and overall performance but also streamlined the identification and resolution of potential issues.

Maintenance represents an ongoing and integral aspect of the application's life cycle. It entails continuous monitoring and updates to sustain optimal functionality post-deployment. This iterative process allows for the incorporation of user feedback, addressing any emerging issues, and adapting the application to evolving needs. Maintenance serves as a commitment to ongoing

improvement, ensuring the application's enduring relevance and effectiveness in the dynamic landscape of computer networks.

4.3 Tool Selection

The development of this application was a meticulous process that involved the adept use of several technologies, each serving a distinct purpose in shaping the system's architecture. Among these technologies were PHP/MYSQL, JAVASCRIPT/JQUERY, and HTML/CSS/Bootstrap. In order to run the application, we chosen to use DOCKER.

PHP/MYSQL: PHP, Hypertext Preprocessor, is a server-side scripting language renowned for its flexibility and compatibility with various databases. In conjunction with MYSQL, an open-source relational database management system, PHP enables dynamic content generation and seamless database integration. MYSQL, recognized for its speed and reliability, stores and retrieves data efficiently, making it an ideal choice for managing the vast dataset inherent in the application. The robust synergy between PHP and MYSQL lays the foundation for a resilient and scalable backend infrastructure.

JAVASCRIPT/JQUERY: JavaScript, a scripting language commonly employed for web development, adds interactivity and dynamic features to the application. It operates on the client side, reducing server load and enhancing user experience by enabling real-time responses. JQUERY, a fast and concise JavaScript library, simplifies complex tasks such as DOM manipulation and event handling. This combination ensures a smooth and responsive interface, elevating the overall user engagement and interaction within the application.

HTML/CSS/Bootstrap: HTML (Hypertext Markup Language) provides the structural framework for web content, defining the layout and arrangement of elements. CSS (Cascading Style Sheets) complements HTML by determining the visual presentation, ensuring a cohesive and visually appealing design. Bootstrap, a front-end framework, builds upon HTML and CSS, offering a responsive grid system and pre-designed components. This facilitates the creation of a mobile-friendly, aesthetically pleasing user interface, enhancing the application's accessibility and visual coherence across different devices.

DOCKER: Docker, a containerization platform, plays a pivotal role in streamlining the deployment and scalability aspects of the application. Containers encapsulate the application and its dependencies, ensuring consistent performance across various environments. Docker facilitates the creation of reproducible and isolated containers, mitigating compatibility issues and simplifying the deployment process. This technology enhances the application's portability, allowing it to seamlessly transition between development, testing, and production environments. With Docker, the application gains agility and efficiency, as it can be easily scaled to meet changing demands while maintaining a standardized and reliable runtime environment.

PHPMYADMIN: The application seamlessly integrates with phpMyAdmin, a widely recognized and user-friendly database management tool. The choice of phpMyAdmin aligns with the application's commitment to accessibility and ease of use. This web-based interface simplifies database management tasks, providing administrators and other authorized users with an intuitive platform to interact with the application's database. PhpMyAdmin offers a range of features, including the ability to execute SQL queries, manage tables, and import/export data, contributing to the overall efficiency and robustness of the database management process. By incorporating phpMyAdmin, the application not only ensures a streamlined database management experience but also promotes transparency and user empowerment within the system's administrative functionalities.

In the deliberate selection of this specific combination of tools, a methodical approach akin to assembling a proficient team was employed. PHP/MYSQL, working collaboratively, established a robust foundation capable of seamlessly managing the substantial data flows within the application's database. Taking a prominent role, JavaScript/JQuery demonstrated prowess in enhancing user experience through effective interactivity and responsiveness. The trio of HTML/CSS/Bootstrap played a crucial part in crafting an interface distinguished by both visual sophistication and universal accessibility across diverse devices. In the background, Docker assumed a pivotal role, orchestrating a seamless and scalable performance across various operational environments. This curated selection of tools, resembling the meticulous formation of a skilled ensemble, ensures a technologically advanced performance aligned with the dynamic requirements of computer networks.

In facilitating a straightforward deployment process, the application provides a `docker-compose.yaml` file, serving as a configuration blueprint for Docker Compose. This file encapsulates the specifications necessary for orchestrating the application's containers, ensuring a standardized and efficient deployment environment. Docker Compose simplifies the management of multi-container applications, allowing users to define and run services seamlessly. By offering a pre-configured `docker-compose.yaml` file, the application prioritizes user convenience, enabling swift and consistent deployment across diverse environments.

Finally for users seeking to initialize the database effortlessly, the application provides a convenient solution in the form of a file named "webapp.sql." This file encapsulates the database structure, allowing users, particularly administrators or those responsible for system setup, to seamlessly initiate the database with a predefined structure. By utilizing this SQL file, users can efficiently configure the database, saving time and ensuring a standardized foundation for the application.

4.4 Implementation

The application's implementation centers on a versatile database containing questions and answers relevant to specific topics. These questions are systematically categorized based on their thematic alignment, allowing for a structured organization. The categories include various sections, offering flexibility for different subject areas, and administrators have the option to add additional categories as needed.

Within the application, two distinct user roles exist. Administrators/ Professors assume a managerial role, overseeing user accounts and system functionality. Additionally, they are required to contribute to the system by uploading questions. These questions encompass a range of formats, such as multiple-choice and matching questions. The application's adaptability extends to the customization of question categories, accommodating a broad spectrum of subjects beyond a predefined set.

Questions uploaded by professors are not limited to a specific exam format but can encompass various assessment types. For each question, the uploading user defines the correct answer and

provides an accompanying explanation for its correctness. This structured approach ensures that the application caters to diverse educational contexts and assessment methodologies.

Additionally, the application empowers professors and experts by offering the option to include visual elements such as photos within the questions they upload. This feature enriches the learning experience by providing a multimedia dimension to the assessments. Incorporating images into questions allows professors to create more contextually rich and nuanced scenarios, enhancing the overall quality of the assessments. Visual aids can clarify complex concepts, simulate real-world situations, and promote a deeper understanding among students. This functionality not only diversifies the assessment formats but also aligns with modern pedagogical practices, recognizing the value of visual learning in reinforcing key concepts.

Users or Students is an other user category, in which the application offers a tailored and user-friendly interface designed to enhance the learning experience. Students can access a variety of questions spanning different topics and difficulty levels, providing a comprehensive resource for self-assessment and knowledge reinforcement. The user-friendly design ensures intuitive navigation, allowing students to seamlessly interact with the system. As part of the inclusive features, students also have the option to track their progress, review their performance history, and receive instant feedback on their answers. This user-centric approach aims to empower students in their learning journey, fostering a dynamic and engaging educational experience within the application.

Moreover, Users or Students, benefit from the application's efficient organization through category-based searching. This functionality allows users to streamline their learning experience by accessing questions categorized under specific subjects or topics. Whether preparing for a particular exam section or focusing on a specific area of study, the category-based search feature enhances the precision and relevance of the learning materials available to users. Additionally, the application facilitates a seamless exploration of its extensive question database through a dedicated search box. This search functionality empowers users to locate specific questions swiftly, providing a user-friendly and time-efficient means of accessing targeted information within the broader scope of the application's database.

5. CHAPTER 4th: Practical Part - Application Development

5.1. Application Deep Dive

The console that was designed and implemented is a system that an administrator user can create new questions and a user can read and learn about networks. The console is a system in order to use for any subject but in our case it concerns questions that are relative to computer networks.

The test is designed to upload a description of a question, but also to be accompanied by files and explanations of the solutions (feedbacks).

The answers are Multiple Choice that the user can choose the correct options.

The system includes two type of users, administrator who can upload the questions and answers as well as their content, and users that can read and learn from them.

Users can enter in a page with all the questions. He can view them serially or using an easily search by section or question contents.

The contents (questions and answers) are saved in a database with the name webapp. Entity Relationship (ER) diagram of Database is the following:

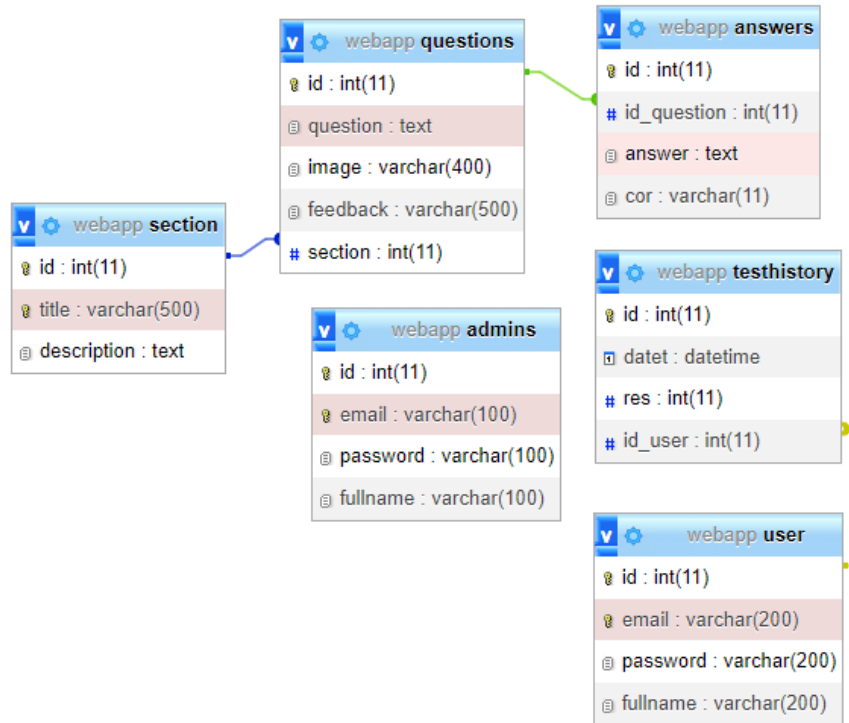


Figure 1 Schematic representation of the application database

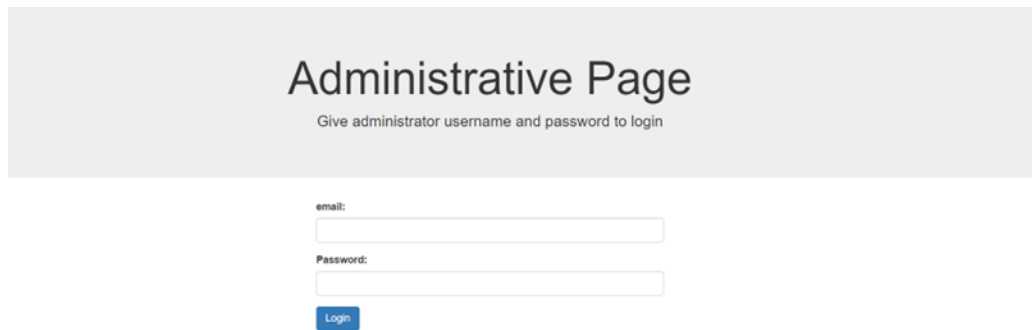
We used the following technologies:

JAVASCRIPT/JQUERY for the Front End

PHP and MYSQL for the backend.

To install the system we used Docker where we install the database given in the webapp.sql file by using the phpMyAdmin container

The system administrator enters the following page:



The image shows a web page titled "Administrative Page" with a subtitle "Give administrator username and password to login". Below the subtitle, there are two input fields: "email:" and "Password:". The "email:" field contains the text "admin@admin.gr" and the "Password:" field contains "1234". A blue "Login" button is positioned below the password field.

Figure 2. The system administration home page

Administrator enters email and password:

The default admin username and password is:

admin@admin.gr

1234

Administrator use the following url:

localhost/admin

After login the page has this view:



This class is used to create questions for users to assess their knowledge on computer networks.

You can create and insert questions that will help users to read and pass exams.

Figure 3. Console update message to user after logging in to localhost/admin

Administrator can click “Administrator” from main menu and he/she take the following page:

The screenshot shows a web interface with a dark navigation bar at the top containing the following links: System, Home, Administrators, Users, Sections, Questions, and a Logout button. The main content area is split into two panels. The left panel, titled 'New Administrator :', contains three input fields labeled 'Email:', 'Password:', and 'Fullname:', followed by a blue 'Create' button. The right panel, titled 'Administrator List:', displays a table with two columns: 'email' and 'Fullname'. The table contains one row with the values 'admin@admin.gr' and 'adminadmin', and a 'Delete' button to the right of the row.

email	Fullname	
admin@admin.gr	adminadmin	Delete

Figure 4. The console login environment as administrator

On this page the user can add new administrators or delete them from the system.

The user also can pass categories to which any questions belong by pressing the SECTION option

The screenshot shows a web interface with a dark navigation bar at the top containing the following links: System, Home, Administrators, Users, Sections, Questions, and a Logout button. The main content area is split into two panels. The left panel, titled 'New Section :', contains two input fields labeled 'Title:' and 'Description:', followed by a blue 'Create' button. The right panel, titled 'Sections:', displays a table with two columns: 'Title' and 'Description'. The table contains three rows, each with a 'Delete' button to the right of the row.

Title	Description	
Introduction to Networks	Introduction to Networks	Delete
Switching, Routing, and Wireless Essentials	Switching, Routing, and Wireless Essentials	Delete
Enterprise Networking, Security, and Automation	Enterprise Networking, Security, and Automation	Delete

Figure 5. The environment for creating categories to which a group of questions will belong

On this page the administrator can easily pass the categories or delete them.

The option QUESTIONS on the main menu administrator can create and save new questions and their answers.

A question has the text of the task, the feedback which is the explanation of the correct answer and the answers.

Pressing Edit on the left of each question, administrator can create the answers:

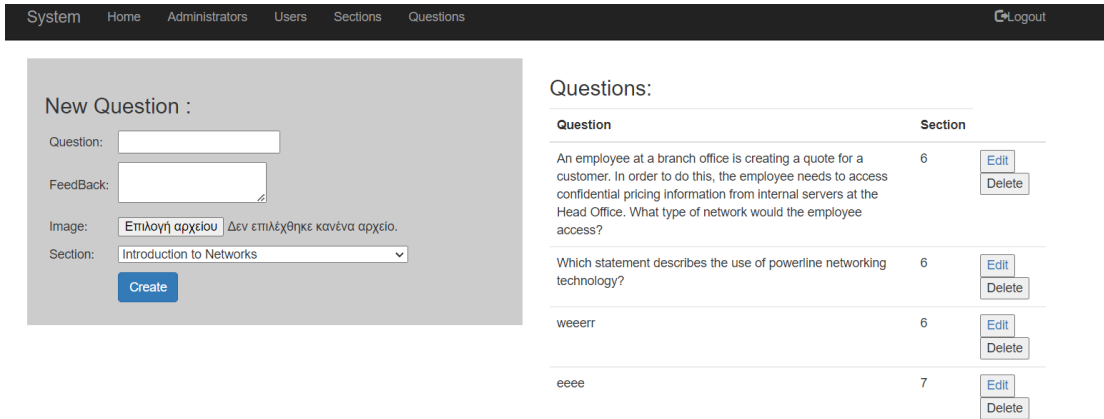


Figure 6. The query creation environment

When the administrator is finished, a simple user can use the site in order to learn from questions and have an exam.

Administrator can add users (students) in the system that they can make tests or learn from the questions.

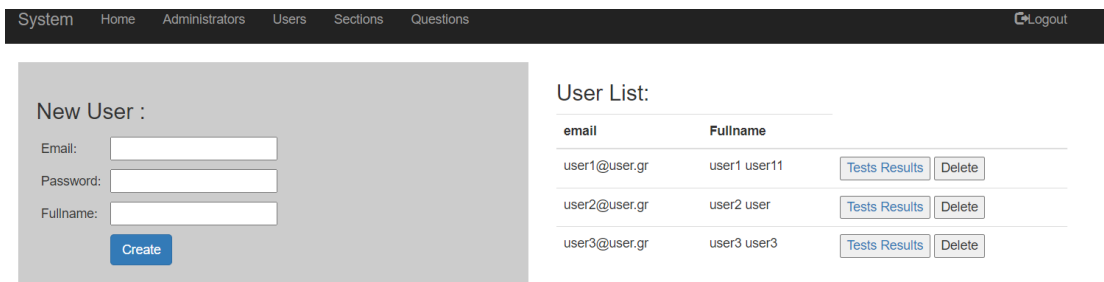
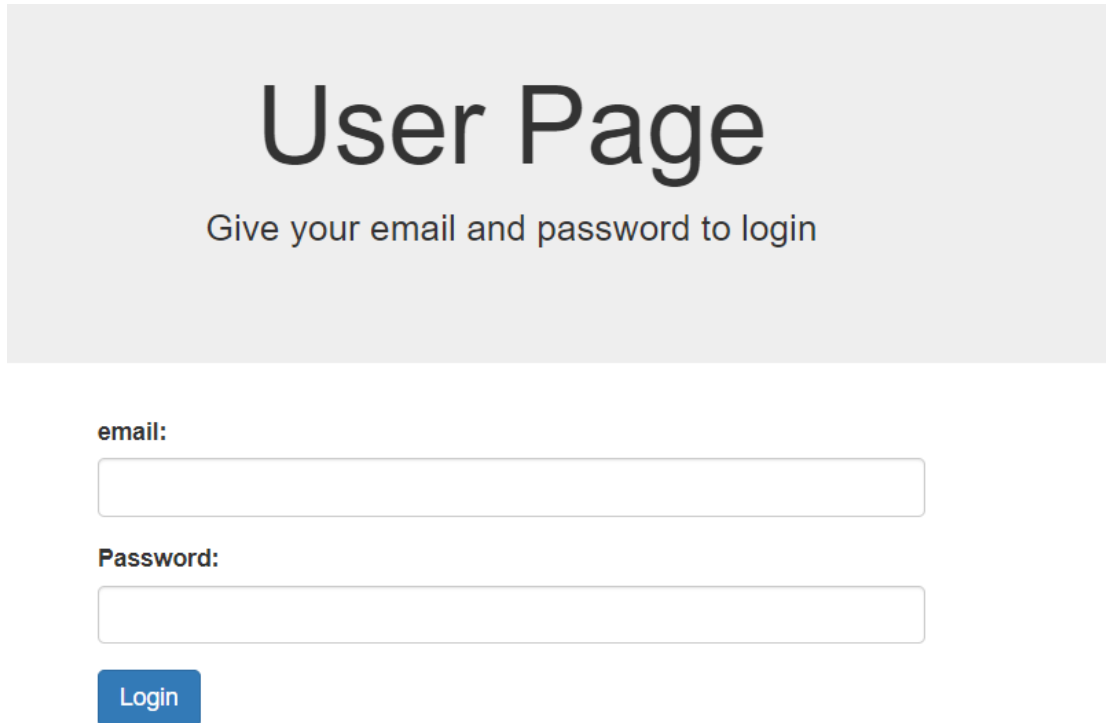


Figure 7. The users creation environment

For each user, administrator can see the tests results and learn about the scores of the user.

Administrator also can delete a user.

The url of the user page is: localhost/user



The image shows a login form on a light gray background. At the top, the text "User Page" is displayed in a large, bold, dark gray font. Below it, the instruction "Give your email and password to login" is written in a smaller, dark gray font. The form consists of two input fields: the first is labeled "email:" and the second is labeled "Password:". Below the password field is a blue button with the text "Login" in white.

Figure 8. The user page.

The user gives his/her email and password and login to main page.

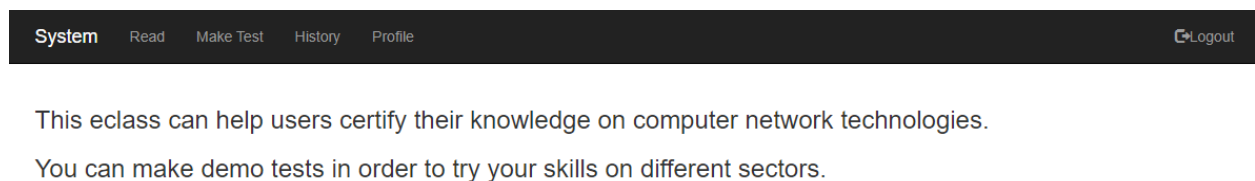
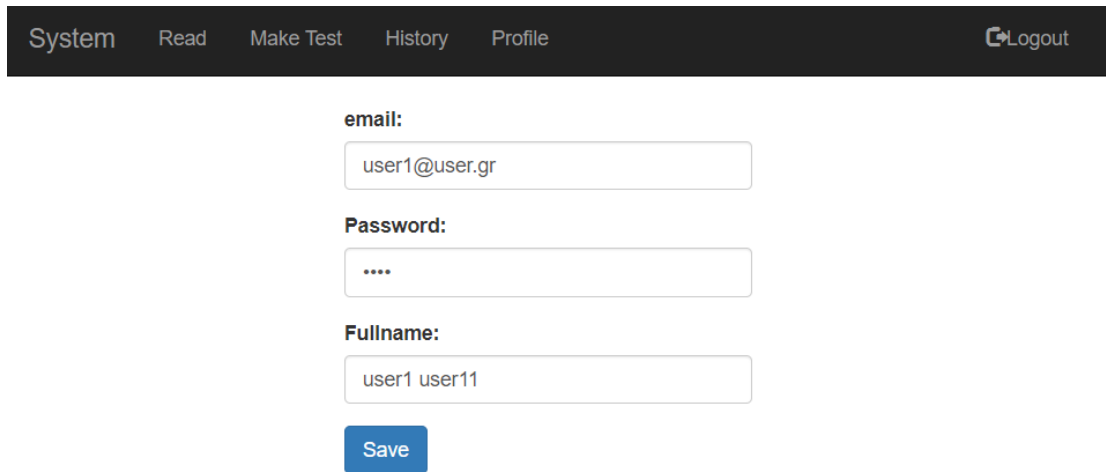


Figure 9. Console update message to user after logging in to main page.

The user can read questions of the Tests, can make test, can see his results (history scores) and he/her change their details like email, password, fullname.

The profile page is the following:



System Read Make Test History Profile Logout

email:
user1@user.gr

Password:
....

Fullname:
user1 user11

Save

Figure 10. The profile page.

The Read page has a list of questions with answers as well as feedback to understand why an answer is the correct.

The page has a direct filter for questions based on their text or category or a combination of these.

The page looks like below:

System Read Make Test History Profile Logout

QUESTIONS

Read in order to have success

Search: Section: All

Question code:7: An employee at a branch office is creating a quote for a customer. In order to do this, the employee needs to access confidential pricing information from internal servers at the Head Office. What type of network would the employee access?

Section:
Introduction to Networks

Answers:

1. an intranet - Correct Answer
2. the Internet
3. an extranet
4. a local area network

Feedback:

Figure 11. The user-student environment for answering questions

The user can filter the questions and see immediately what he/she wants according to the category but also by part of the text and keywords.

Each question has a fixed number for a code, and if the user wants to see it again, he can write on the search field a text like "code: 7"

The user can make tests with the option "Make Test"

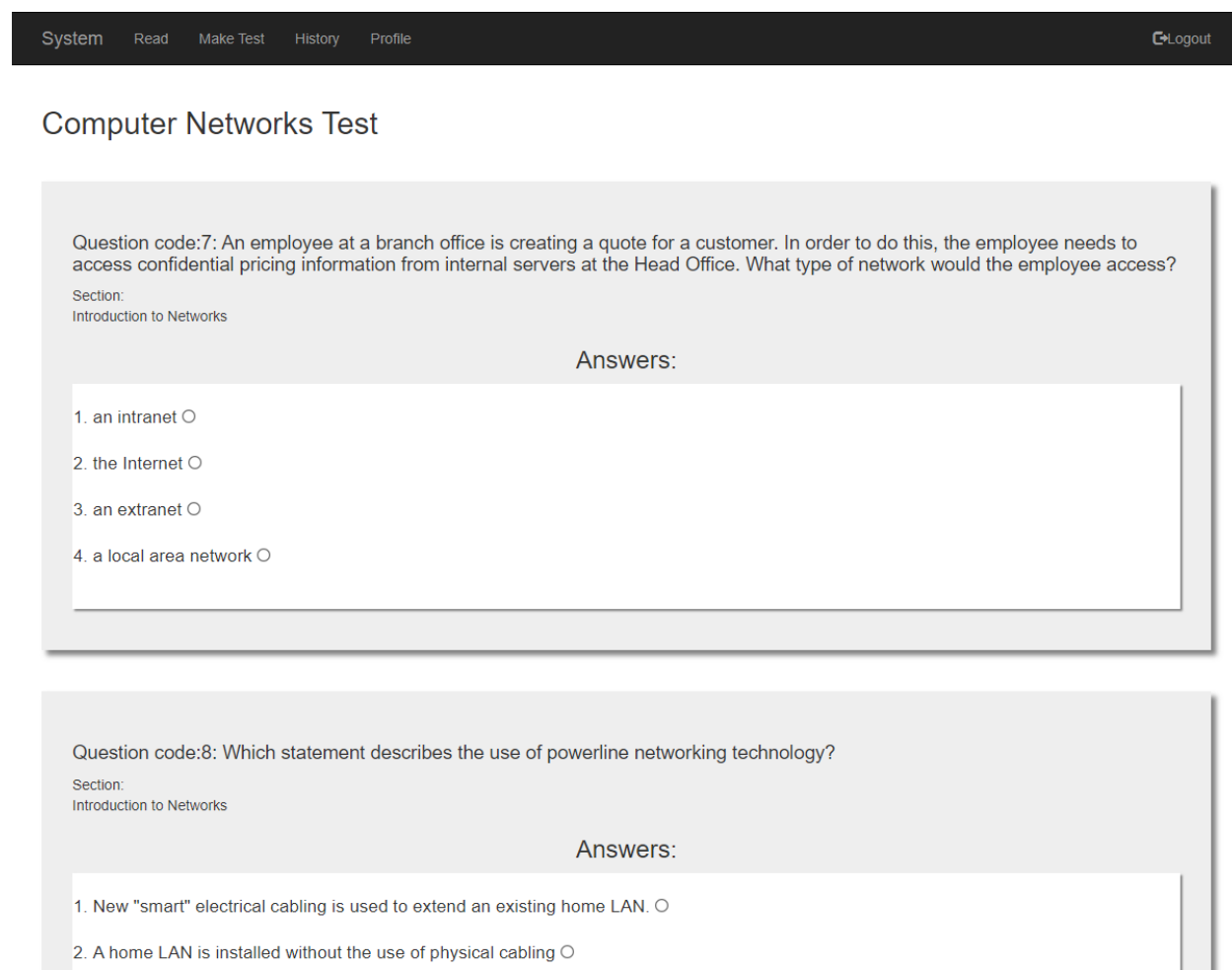


Figure 12. The user-student environment for answering questions

When the user complete all the answers will take the result. The results will be saved and if the user choose the option history from the menu will take the following result:

The image shows a screenshot of the 'Tests History' page. At the top, there is a navigation bar with links for System, Read, Make Test, History, Profile, and a Logout button. Below the navigation bar, the title 'Tests History' is displayed. Underneath the title is a table with two columns: 'Date' and 'Result %'. The table contains two rows of data.

Date	Result %
2023-06-26 20:58:13	25
2023-06-26 21:04:00	25

Figure 13. The results page for the students

6. Conclusions

In conclusion, this thesis has developed an application that provides a practical means for individuals to prepare for any computer network exam. The application features two categories of users: administrators and professors/experts, and users who want to prepare for the exam. The significance of the application developed in this thesis lies in its ability to provide an effective means for individuals to prepare for the exams, which is a highly sought-after certification in the field of computer networks.

The development of the application involved the use of several technologies, including PHP/MYSQL, JAVASCRIPT/JQUERY, and HTML/CSS/Bootstrap. The system's architecture is designed to ensure that the questions and answers are properly categorized and stored in a database format that facilitates easy retrieval. The user interface is user-friendly, allowing users to navigate easily through the system's various features. The system is also scalable, allowing for the addition of new questions and users as the need arises. This design ensures that the application is secure and reliable, protecting user data and providing a smooth user experience.

In addition to the development of this practical application, the study highlights the importance of training in computer network technologies and the role that educational applications can play in facilitating this process. The study provides an overview of the various training programs and certifications available in computer network technologies and the role of educational applications in improving the training and certification process. Furthermore, the study highlights the need for further research and development in this field to continue to improve the training and certification process in computer network technologies.

While the study focused on the development of a specific application, the potential of cutting-edge technologies of Large Language Models (LLM), like ChatGPT, Gemini, Bard, Davinci, Lama etc., in revolutionizing education cannot be ignored. With the ability to generate human-like responses to natural language inputs, LLMs have the potential to create intelligent tutors that can adapt to the needs and learning styles of individual students, and provide more convenient and flexible access to information. However, it is important to carefully consider the potential challenges and limitations of such technologies, including privacy concerns and the potential for reducing the

need for human interaction in the learning process. As technology continues to evolve, it will be important for educators and educational institutions to assess both its benefits and limitations in order to make informed decisions about its use.

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