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Issues in Hands-on Online Graduate Programs in Information Technology

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Abstract

There is a high demand for online graduate programs in various engineering and technology fields. The reasoning is simple: there is a large pool of working professionals needing graduate study, but cannot afford to in-person due to their job, family, or distance limitations. The Department of Technology Systems, within the College of Technology and Computer Science (TECS) at East Carolina University has been offering several Internet-based graduate programs since 1995. This paper focuses on the Master of Science in Industrial Technology (MSIT) that has several concentrations, including Computer Networking Management, Digital Communications, and Information Security. All courses in the MSIT program are delivered 100% online, with majority of the technical courses having lab-intensive, hands-on components. This paper shares information pertaining to some of the issues and experiences of offering graduate, hands-on programs in information technology (IT) completely online.

Introduction

Distance education, by nature has several unique issues, but making it online and lab-intensive with real equipment creates new challenges[1,3,5,13]. The availability and affordability of computing and networking technologies have made Internet-based teaching and learning of both theory and lab-based courses and programs very practical[1,5,9,13]. Advances in Internet access technologies like dial-up, broadband, satellite, and personal wireless communication services have propelled online teaching and learning to unprecedented levels. Additionally, the tremendous processing power and reduced cost of today's personal computers and networking equipment have made Internet-based programs much more appealing and practical than other traditional DE based counterparts. As a result of these and other technological developments, there is a flurry of activity as academic institutions attempt to capitalize on this new wave of enrollment-boosting opportunity[2,5,7-12].

Initial developments in online lab-based programs were dominated mostly by theory-based courses, or those that easily lent themselves to simulation[5,9,10,13]. Courses and programs that needed control, programming, and manipulation of real equipment either required the DE students to travel to campuses or designated locations for a chance at real lab experiments[2,3,11]. In some cases, instructors were forced to haul the lab equipment to remote locations for the students to practice with over short periods, or in other instances over several days. This method was not very conducive or practical for some of the students, or even the instructors for several reasons.

First, requiring the students to show up at some preselected locations or times causes undue hardships for some of them due to family, job, distance, or other personal limitations. This also defeats the whole concept of "any time, anywhere learning" that makes Internet-based courses and programs so attractive. Second, there are associated risks and expenses if the students are required to either take time off work, accommodate themselves at some location other than home, or haul themselves over long distances. These incidences may sometimes cause the students to reconsider their intents for graduate study. Third, moving equipment to some remote location(s) is time consuming and carries some degree of risk of loss and/or damage, and deprives the school of its potential use to teach, learn, or conduct research.

Ideally, hands-on, online graduate programs should allow the students to learn the required material at their convenience; permit adequate interaction with instructor and among the students; conduct hands-on exercises anytime and anywhere; individualize instruction to capitalize the varied backgrounds and experiences of working professionals; provide adequate and up-to-date equipment for relevant and uninhibited exploration and experimentation; and much more[1-13]. The ECU online MSIT program will be discussed in the next section, followed by issues and experiences in implementing this lab-based graduate program.

The ECU graduate online program

The graduate MSIT degree and certificate programs at ECU have evolved over a nine-year period, and have been designed to meet the demands of working professionals. Students can choose from a variety of IT emphasis areas including Computer Networking Management, Digital Communications, and Information Security. The bulk of the technical courses have significant hands-on components that utilize real equipment to provide laboratory environments that are fully accessible over the Internet. Most of the students in the program are professionals holding full-time jobs at community colleges, in the military, or in private and other public sectors.

The ECU program grew out of strong needs for affordable, graduate, DE based, hands-on technology programs in information technology for students who would not otherwise be able to physically attend a college or university due to work load, family commitments, distance, or other limitations. To that end, the online programs at ECU are designed to provide maximum flexibility for the working professionals, allowing them to take courses, conduct hands-on lab activities and projects, and collaborate with their classmates in their available time.

For on-line or Internet-based programs to be successful, however, several key issues must be addressed. These include advanced planning, pedagogy, laboratory equipment selection and setup, delivery tools, and other techniques for making the online, lab-based DE programs equally as challenging as their face-to-face counterparts. These issues will be addressed in the sections that follow.

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Planning for online lab-based IT courses

Advanced planning is a critical first step to successful lab-based online programs in IT. Instructors need to obtain comprehensive, accurate and up-to-date background information from each student well before the semester begins. For those students who register late, their background information should be collected immediately. Unlike most on-campus face-to-face populations, graduate DE students are typically more diverse, ranging from novices who have just completed their baccalaureate degrees, to seasoned professional at the brink of retirement and with many years of experience under their belts.

The initial information obtained from the students will be crucial in ensuring that the instructor plans adequate accommodations for individual differences in backgrounds and range of abilities. It will also help the instructor plan appropriate activities that will capitalize on the more advanced students who possess skills well beyond the scope of the course at hand. Such students can help teach segments of the course, help assess or troubleshoot lab work, help pilot-test future labs and identify potential flaws before the rest of the class attempt the exercise(s), or develop unique exercises that could be used in the class. Additional opportunities for the advanced students could include research other creative activities that will help improve the quality of the course at hand.

Having fore knowledge about the students helps instructor plan for adequate equipment for the remote labs. It is a good idea to plan for extra equipment, especially servers, to help minimize disruptions and alleviate frustrations from students whose servers have failed for any reason.

Another key planning issue for lab-based, Internet programs is ensuring that adequate measures are in place to guarantee reliable connectivity to the remote equipment. Today's university networks are bombarded with unsolicited and/or unwanted traffic. This has caused network administrators to become more cautious and more aggressive in monitoring traffic, as well as, take prompt and decisive actions on any suspicious activity, such as increased traffic on the network or sub-network. To that end, it is imperative that the institutional network administration be involved in the initial planning stages for all online labs. These administrators need to have first-hand knowledge about any proposed remote labs, the range of IP addresses that will be involved, as well as any non-standard port numbers that may be utilized. This is a necessary step that will help alleviate frustrations and excitement for both the students and the instructors due to decisions to shut down ports that have a flurry of suspicious, but legitimate activity.

Laboratory Design and Implementation

Due to the nature of content in the Information Technology field, laboratory activity is an important component. Hands-on exercises not only allow the students to further understand abstract theories and concepts, but also gives them some opportunity to explore practical aspects of technological applications that may not be addressed in textbooks. More than half of the technical courses in the MSIT curriculum involve hands-on laboratory activities that are conducted purely over the Internet.

Designing laboratories for online, lab-based IT programs could prove quite challenging and expensive. This is partly due to the rapid evolution of information technologies, and shrinking educational budgets. Carefully planned IT labs must be very reliable, secure, and have some built-in redundancies to safeguard against any unexpected failures. Ideally, instructors of lab-based courses should worry more about learning outcomes than equipment and network up time. A sample remotely accessible online lab topology is shown in Figure1.

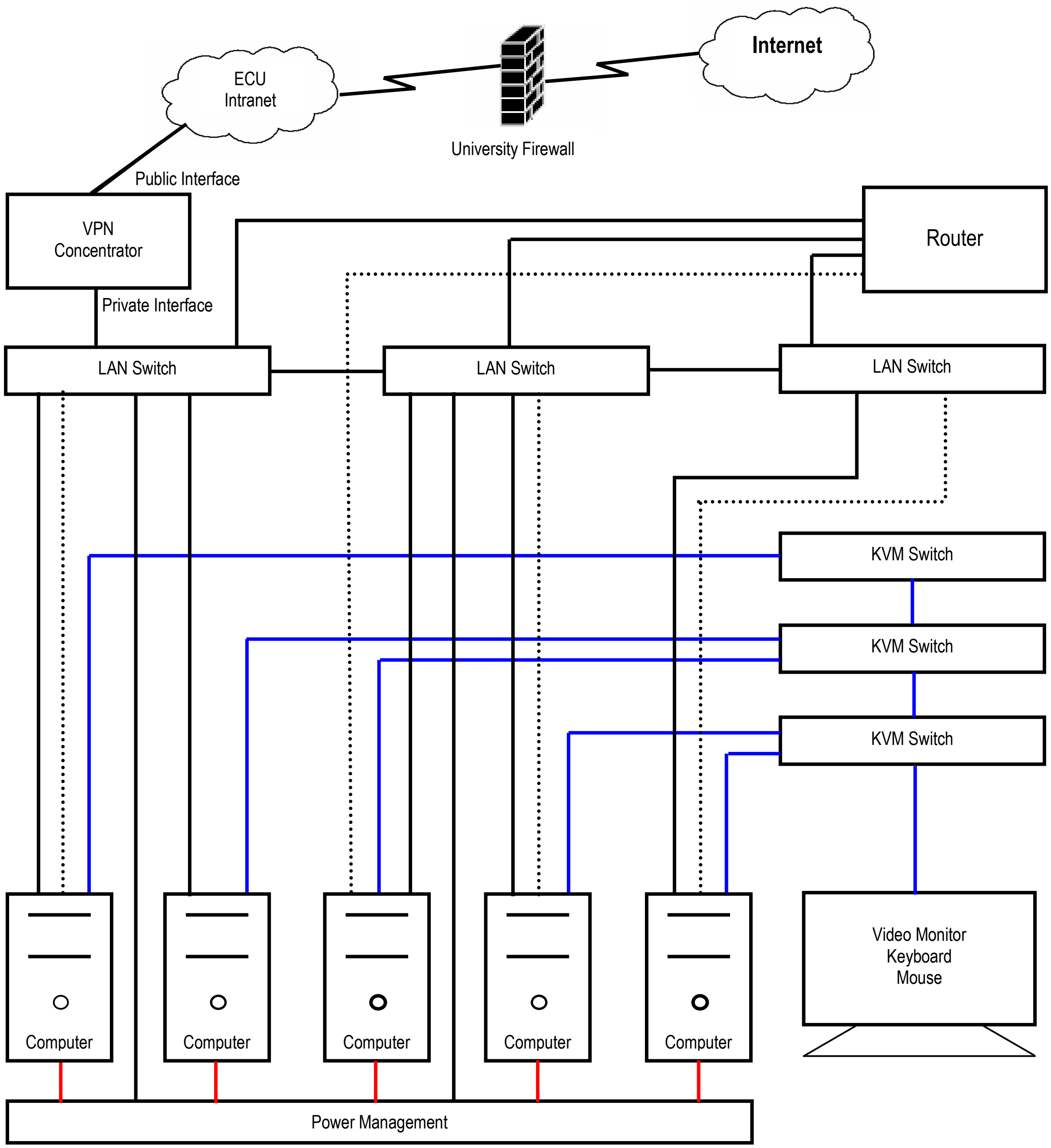

Figure 1. Block diagram of one of the ECU MSIT online lab implementations.

When planning online laboratories, one of the issues that need to be addressed include ensuring that the lab are optimized to provide opportunities for exploration and experimentation opportunities among the students. Such flexibility needs to be built into the network topology, power management module(s), as well as in all clients and servers. Additionally, adequate safeguards need to be in place should something go awry. Instructors should have full access and ability to remotely control any piece of equipment residing in the remote lab.

The ECU MSIT online labs have evolved from a merely six-server lab at the inception of the program nine years ago, to more than 200 servers, and several routing and switching equipment racks that support various courses in the program. This growth is attributed to significant investments by the university using a portion of the revenue generated by the increasing enrollments. Currently, the labs are equipped to support three primary areas in the MSIT degree program, each with its own set of laboratory equipment requirements. The three areas are Digital Communications, Computer Networking Management, and Information Security concentration.

In the Digital Communications concentration, lab exercises are centered on network service design, installation, and configuration. The lab equipment needs are primarily network server computers and workstations, with a few routers, switches, and remote access supporting devices. A cross section of the Digital Communications lab is shown in Figure 2.

Figure 2. Digital Communications remote access lab.

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In the Computer Networking Management concentration, lab exercises are centered on networking infrastructure design, configuration, and troubleshooting. Naturally, the lab equipment must include switches, routers, server computers, workstation, and other network devices, such as Voice over IP devices, and Storage Area Network equipment.

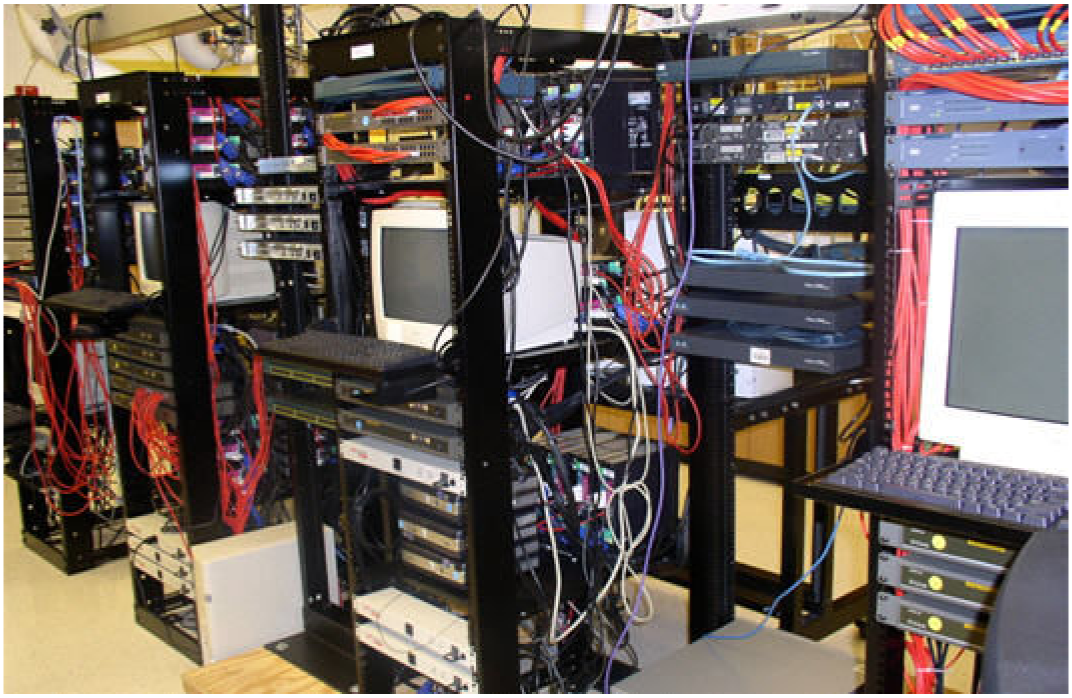

Figure 3. Operating systems and network management racks.

In the Information Security concentration, lab exercises are centered on intrusion detection and protection of information systems. Thus, in addition to switches, routers, servers, and workstations, other devices, such as network sniffers and intrusion detection sensors are provided. A cross section of the information assurance lab is shown in Figure 4.

Because courses from each concentration can be offered simultaneously in the same semester, multiple sections of the online labs will need to be setup before each semester starts. Faculty members and lab assistants work together in setting up and maintaining the lab equipment.

In addition to physical equipment, another issue that instructors need to think about is that of access and control of the remote equipment over the Internet. To that end, careful selection of commercial remote access software will be essential for successful laboratory experiences. Available remote control packages include pcAnywhere, GoToMyPC, RemotelyAnywhere, and much more. When deciding on remote control platforms, one must carefully select from a myriad of choices, ranging from those that allow direct access to the remote labs, to those packages that first divert all remote access requests to their parent companies for authentication, and then to the remote labs. Obviously, the added overhead of the second option is not very popular.

Figure 4. A cross-section of the Information Assurance laboratory.

Our faculty and staff evaluated several remote access and control packages and chose to implement RemotelyAnywhere in some of the courses. Additionally, some instructors add Microsoft Windows Remote Desktop connection due to its speed and improved security features. Both packages are implemented over secure communications channels.

Last, but not least, laboratory planning must include security issues, along with measures to be taken should problems emerge. Remote access to labs is actually not a security threat since both RemotelyAnywhere and Remote Desktop Connection can be implemented with Secure Socket Layer (SSL) over the Internet. In the early stages of our programs, student servers had valid public IP addresses and were assigned to the students for their exercises and explorations. To encourage these experiments and explorations, very few restrictions were imposed on the use of the servers. Due to an increase of hacking over the internet, these servers quickly became targets of repeated attacks. Several systems were compromised and used to generate illegal traffic on the university network. In some cases, malicious packet-generating utilities were installed and activated at random times creating significant amount of traffic on the university network.

These and other activities quickly received the attention of the campus Information technology and Computing Service (ITCS) who took decisive actions to isolate the affected systems by shutting down all ports leading to/from them. As would be expected, these actions proved to be quite frustrating for both students and instructors. As a result, ITCS raised some issues pertaining to remote server-based (most affected) labs, two of which are listed below:

1. Due to nature of lab exercises, students might inadvertently enable some network services that could disrupt the normal network operation of the campus network infrastructure. A good example is the dynamic host configuration protocol (DHCP) service.

2. The more serious issue stems out of concerns that the lab server computers might not have necessary protection due to the minimal configurations and limited restrictions imposed on them. These perceived vulnerabilities makes the computers prone to malicious attacks and, once compromised, might be used as zombies to launch attacks on the internal network.

To address these issues, it was apparent that network devices in the online labs needed to be placed on a separate network segment, isolated from the campus backbone. Secondly, if a security device were placed in the front of the isolated network it would address the second issue raised by ITCS. After reviewing various solutions, a decision was made to move the affected networks behind Virtual Private Networking (VPN) technology with Cisco VPN concentrators. This step immediately eliminated external threats, and allowed authenticated users to have full access to the remote labs and equipment. This secure environment also permitted experimentation with devices and services that would have otherwise proved problematic outside the VPN, like DHCP for example. The online laboratory was redesigned and several VPN concentrators were added to different segments of the online labs.

Another issue posed by the implementation of VPN technologies is that of support for various operating systems and environments. VPNs use tunneling protocols to create secure connections among remote computers. Due to the diverse nature of our students, selection of tunneling protocols must take into account a range of possibilities for different operating systems and capabilities that student computers can support

Another area of concern emanates from internal threats posed by the use of generic access account and login credentials and pass phrases. Some of the servers and remote access equipment were initially set up with generic accounts and pass phrases, but this decision quickly proved unwise as some of them became compromised by the students. It is therefore suggested that unique pass phrases be utilized on all network servers and networking equipment, along with appropriate logging to help document and isolate sources of problems. Additionally, instructors should create "back doors" that will allow them to access and unlock, repair, or upgrade any of the systems.

Delivery Tools

The major attraction for DE programs is their ability to provide anytime, anywhere learning opportunities to students located around the globe, as well as mobile professionals or military personnel. Centralized course management systems help in the delivery of course content using interactive and user-friendly interfaces. At ECU, a handful of course content management systems like eCollege, Blackboard, and WebCT were evaluated, and the Blackboard system was selected.

In addition to Blackboard, the College of Technology and Computer Science houses a fully functional global classroom that provides state-of-the-art facility for real-time, or streamed multi-media instruction/production. This facility offers both synchronous and asynchronous means for creating and delivering multimedia-rich content in real-time, or asynchronously from archived storage. An image of the control room for the global classroom is shown in figure 5.

To enhance availability and adequacy of delivery tools, some units supplement the Blackboard system with extra departmental servers that are used to provide services that Blackboard system does not offer. For example, web servers may be used to provide streaming audio and video components in which faculty teach segments of course content. Others servers provide secure FTP service for students to submit their assignments, or download other supplementary materials.

Figure 5. Global Classroom control room.

Another key aspect of Internet-based programs is interaction. Interaction is a fundamental task and integral component of DE programs and helps the online students feel that professors are equally accessible to them as the on-campus students do. Several tools are used to provide effective interaction between professors and students. These include frequent and timely email; synchronous chat, audio, video conference sessions (held weekly, and/or as needed); telephone calls; and "virtual" online office hours using IP-based video conferencing technology. General comments among the TECS faculty suggest that DE students, on average, have more interactions with professors than typical 20-year-old, face-to-face college students.

Interaction among students is one of the elements that makes them feel they are part of a community instead of isolated individuals. In addition to emails and chat sessions, other opportunities are provided for their community bonding, such as Yahoo Groups where students can discuss group projects, pose questions to each other or to the instructor, or solicit assistance when needed.

Many of our students are taking DE courses for the first time while some of them have some DE experiences. In order to prepare all students to be successful in Internet-based DE courses, a decision was made to require new students to take an introductory course that exposes them to the various Internet tools used in the curriculum. This course covers many technologies and applications used in the DE program for course material delivery, interaction, group projects, and most importantly, communication among instructors and students. Success in this course is crucial due to the nature of the curriculum since subsequent courses expect the skills to be put to use.

Summary

In this paper, the authors have presented some issues regarding the planning and implementation of graduate, hands-on, online programs in information technology. Advances in technology, increasing demand for Internet-based programs, and reduced cost of computing and networking equipment have made it possible for many institutions to participate in the creation and delivery of online courses and programs.

For hands-on, internet-based courses to be successful, however, several issues must be addressed. These include advanced laboratory planning, equipment procurement, installation, and configuration; careful selection of strategies for maximizing learning outcomes for students with a wide range of abilities; careful selection of delivery tools and remote access packages; creation of redundancies and safeguards that insure minimum interruptions due to equipment or other failures or mistakes; and implementation of the online labs with minimum threat the to institutional network infrastructure. Other issues include design of flexible topologies that permit independent exploration and experimentation, and techniques for maximizing interactions among students, as well as between students and instructors.

Feedback from graduates indicates some degree of satisfaction and appreciation for the opportunity afforded them to fulfill their dreams. The following are excerpts from voluntary feedback received from program graduates:

- *"Because of my busy schedule as an instructor at a local community college, ECU provided me with a wonderful opportunity to continue my education in an online environment; this helped me achieve a goal I had wanted to complete for more than 20 years. I am very grateful to ECU for being in on the cutting edge of technology! Distance Learning classes have ultimately changed how a student is able to obtain a college degree. Continuing my college education was a wonderful and fulfilling experience, so much that I have decided to continue onward to pursue my doctorate degree."*

- *"I am one of your former students in the Digital Communications program I graduated May 2002. I just wanted to let you know that my masters degree at ECU had a profound effect on obtaining a Security Managers position with …[identifying information has been removed]. Since my graduation I have obtained three security certifications and also been asked to teach and do public speaking engagements on Wireless Security. … My masters research has been the launching pad to my career in the Information Security Field. Thanks again you are a credit to the field and to the university."*

- *"I would like to let everyone know that I was just selected to fill the position of Wireless Systems Engineer for the telecom that employs me. The selection is a direct result of completing the MSIT program …, I will be working with the rollout of a 2.5G/3G network, and research, development, & implementation of applications (project management) for the network. All of which tie into my graduate project. Thank you for the sound grounding and training you gave me in digital communication!"*

The ECU MSIT graduate program has been grown steadily since inception in 1995. This growth has led to significant increase in resources including funding, equipment, and faculty (which has more doubled in size)! The IT programs offered are very technical and hands-on in nature, providing both hardware and software experiences in enterprise network system design, implementation, and management; network security, intrusion detection, incident response and security system design and management. These areas require significant and sustained investment in equipment, as well as faculty and staff development, both of which have been possible due to program growth.

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Biography

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