Internationalized approach to wireless networks simulation

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***Abstract* — In this work we describe how a wireless sensor network simulator was integrated into a 3D environment for use in multi-lingual teaching environment. It has been known that simulators are very useful as supplement to a physical equipment in the classroom; the idea in creating internationalized environment was to help Libyan students studying in Serbia overcome the language barrier and organize virtual sessions according to their learning profiles and cultural habits, which is not possible in a traditional classroom setup.**

***Keywords* — 3D environments, education, internationalization, network simulation.**

I. INTRODUCTION

Teaching computer network courses has always been considered a challenging task for both students and teachers; in order to ease this task, various network simulators have been introduced to be used as an educational tools. In this paper we describe how a wireless network simulator implemented in Java was integrated into interactive 3D virtual lab in different languages: Arabic, Serbian, and English. We explore the pedagogical aspects of using such approach in different cultural environments and assess the reaction of Arab students using the simulator in 3D environment.

Wireless sensor network (WSN) simulator we developed enables process visualization and simulation of sensor wireless network. Three instances of the simulator with interfaces in different languages are integrated into open-source 3D toolkit Open Wonderland [1] to be used as teaching tool. The chosen toolkit enables creating the interactive scene that every student can join, take part in computer network course and practice fundamentals of wireless sensor networks using the simulator in the most appropriate language.

This paper is organized as follows: in Section II we present advantages of using simulation in computer networks courses, followed by a survey of network simulators in educational use. Section III is devoted to a related work in the area of network education in Middle East countries. We continue with describing psychological profiles and learning styles of the Libyan students preparing for higher education abroad. In section V we take a glimpse at 3D environment we used in networking courses and discuss the advantages of such approach respect to the traditional ways of teaching. Following is the description of internationalized WSN virtual classroom and the way it was integrated into Open Wonderland. We conclude with the preliminary evaluation of using such approach with the Libyan students studying in Serbia and discuss future work in concluding remarks.

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II. NETWORK SIMULATORS USED IN EDUCATION

Many researchers have provided useful tools for computer network simulation in the last few years; this paper focuses on tools which proved to be reliable for use in the educational domain. Table 1 presents a brief survey of network simulators in active use today [2]; in order to help instructors pick the most appropriate simulator for wireless network courses, we present their main features (programming language, graphical user interface, supported network protocols). Simulators supplement physical equipment in the classroom, allowing lecturers to demonstrate the interconnection between networking theory and relate it to virtual physical equipment. Simulators help students create a network with almost unlimited number of devices, encouraging practice, discovery, and troubleshooting. The simulation-based learning environment helps students develop skills such as decision making, creative and critical thinking, and problem solving.

WSN simulator eWISENS we developed is designed in Java and models all important networks levels, from the communication to the application layer. Student is able to design and simulate a desired wireless sensor network. The design can be carried out in one of two ways. The first, self-learning way, allows users to design various WSN scenarios on their own, and to explore WSN protocols at their own pace. Users are able to add sensor nodes, change their status, and choose required algorithm from a set of mathematical algorithms available. The second way is focused on the laboratory exercises held on WSN course. The selection of the self-learning opens a blank canvas, where students can add arbitrary number of nodes and select various algorithms from the drop down menu item. Students can use the software system from their home computers and do practical homework, or explore their own scenarios. By using the simulator, students can more easily understand complex WSN topics through visualization.

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TABLE 1: PRINCIPAL CHARACTERISTICS OF NETWORK SIMULATORS IN USE FOR RESEARCH AND EDUCATION.

Tool	NS-2	NS-3	OMNeT++	Wireshark	OPNET	Glomosim/ QualNet	J-Sim	GNS3
Programming Language	C++/OTCL	C++/ Python	C++	C++	C/C++	Parsec C	Java/Jacl	Python, Cisco IOS
License	Open source	Open source	Free for educational use only	Open source	Free for academic use	Open source	Open source	Free, with Cisco IOS
GUI	Limited	Good	Good	Good	Excellent	Limited	Good	Good
Educational Use	Average use	Average use	Average use	Limited	Limited	Limited	Limited	Extensive use
Research Use	Extensive use	Extensive use	Extensive use	Extensive use	Extensive use	Extensive use	Extensive use	Limited
MAC Protocols	802.11 (several implementations), TDMA with preamble	802.11 (several implementations)	TMAC, SMAC, adjustable MAC	/	802.11, 3G, ultra Wide Band, 802.16, Bluetooth, etc.	CSMA, 802.11 and MACA	802.11	/
Routing protocols	DSDV, DSR, TORA, AODV	OLSR, AODV	Simple Tree, Multi-path rings	/	DSR, TORA, AODV, OLSR	AODV, Bellman-Ford, DSR, Fisheye, LAR scheme 1, ODMRP, WRP	AODV, OSPF, multicast, shortest path tree, CBT	/

III. NETWORKING EDUCATION IN MIDDLE EAST: STATE OF THE ART

Recent experiences of teaching electrical engineering courses demonstrate the discrepancy between the theory and practice, and computer network courses are no exception. We will be looking at different experiences in developing countries, discuss the approaches they are following, obstacles they face and describe our approach.
By analyzing different previous experiences, we can notice that in teaching computer network courses one of the following approaches is applied:

- Using physical laboratories in addition to the theoretical lectures.
- Using virtual laboratories in addition to the theoretical lectures.
- Using simulated labs in addition to the theoretical lectures.
- A combination of the three previous approaches.

Paper [3] describes teaching experience in college of computing and information technology at King Abdul-Aziz University in Saudi Arabia. Their curriculum is divided into three specialized disciplines: Computer Science, Information Systems, and Information Technology. Each discipline includes one or more network courses. Different approaches were followed to figure out the best approach to enhance the learning experience through standardized teaching modules and environment. Teaching methodologies include the combination of physical and simulated approaches. The general approach used to deliver the concepts is through presentations, pictures and hands-on experience by interacting with network tools and devices. Beside general approach, videos (demonstrating the procedure and concepts) and task-based learning methodology are used to make lab sessions more valuable, efficient and motivating.
The evaluation in [3] states that students find the lab session is effective, beneficial and remarkable way of learning. Students also judge the physical interaction with network devices and working on more scenarios/exercises as an excellent experience and the most important aid that truly gives them confidence in working in real environments.

Paper [4] from the Department of Computer Engineering, Sheriff University of Technology in Tehran (Iran), describes the use of PARTOV (**P**ortable **A**nd **R**eliable **T**ool for **V**irtualization) simulation engine as teaching tool for the computer networks course. The authors argue that nowadays there are two extremes in teaching computer network courses. The first approach is use of the actual network devices (i.e. routers, switches) and letting students experiment with real devices in various network layouts. Drawbacks of this approach are that each student or workgroup of students must have dedicated devices, which means that the setup of laboratories is very costly. Also, this approach requires physical presence of the students in the laboratory and limits their understanding of the underlying protocols. The second extreme approach is that students use simulator software to simulate different scenarios. The obvious advantage is that this approach does not require dedicated network devices and allows students to work on the assignments outside the class by executing the simulator on their personal computers.

Drawback of a simulator-only approach is that the students are not allowed to go beyond the predicted scenarios of the simulator. Instructors in [4] propose a hybrid approach as a middle road between the extreme approaches mentioned above. In this case, simulators are connected to the physical network topology allowing the students to design, implement, and execute their code on virtual nodes. At the same time, nodes interact in a real world topology (PARTOV tool). The authors claim that the tool they applied improves students' learning, and their ability to simulate dynamic environments similar to that of Internet, an important feature that allows wide coverage of the concepts covered in class.

In [5] at Sakarya University Technical Education Faculty in Turkey DEVS-Suite network simulator is used in teaching a graduate course called Design and Simulation of Computer Networks. The students were required to use the DEVS-Suite and NS-2 simulators in three of their homework assignments. The first assignment was to evaluate the deployment of the tools. For the second assignment, students were asked to develop a network topology composed of 10 routers and 11 links both in the DEVS-Suite and NS-2 simulators with almost the same parameters and underlying protocols. Students were asked to observe how the simulation runs and analyze the results. For the third assignment, students studied scalability aspect of computer networks. Students were required to develop a network topology with a few thousand of nodes using a recursive algorithm. The students simulated these models under varying conditions (experimental settings), analyzed the results, and evaluated the strength and weaknesses of the DEVS-Suite and NS-2 simulators.

In [6] at Riyadh College of Technology in Saudi Arabia an e-learning center was developed in order to improve the educational experience with virtual technology. 3200 students were taking computer course through blackboard learning management system. They argue that the student's feedback on the course was very positive. Some students would have liked the availability of self-evaluating tool, to permit them an active participation in the assessment process.

IV. Psychological profile and learning styles of Libyan students

Cultural factors have tremendous impact on how people learn, including the style of interaction and communication, constituting the core foundation of learning. The language barrier is a significant inhibiting factor in adopting simulators. In Libya in particular, the official language is Arabic, and the level of English skills is very low; however, most of the learning resources, software, and Web contents are in English. The use of simulation software is currently very limited, as there are very few simulators available in Arabic, and the country lacks the capacity to develop its own. The most common used simulators there are NS-2 and GNS3 as they are open source and easy to use, with user friendly GUI.

The language barrier is already by itself a limiting factor for a number of Libyan students who come to study in Serbia, as their country is struggling to improve education by sending students to study abroad. We interviewed a heterogeneous group of 20 undergraduate students, 18 master students, and 48 PhD students from Libya. Although the mastery of English language improves with degree of study, they all experience problems in a new environment. Our initial idea was to create an environment in which the language barrier could be overcome, but which could also allow active use of network simulators.

Despite known initial drawbacks of virtual environments (such as the lack of physical contact between the lecturer and students), based on other universities experiences, we were strongly convinced that the use of network simulator presented in different languages as a teaching aid in computer network courses could only help Libyan students.

Learning styles and students' profile play a vital role in teaching engineering models such as computer networking. Students' learning profile defines a set of characteristics that classifies a student learning process according to a specific model. In Libya, the way students behave could be slightly different, in that they rely totally on the handout which is given by the lecturer in an environment in which the students learn by seeing the whiteboard, hearing the instructor, memorizing and visualizing. To overcome this obstacle, we internationalized our Java based simulator with an Arabic GUI and applied it in teaching networking courses to Arabic students.

V. Network simulator in internationalized 3D environment

Advantages of using 3D simulation in education are well known, as described in [7]; among them, the most notable are:

- Facilitating familiarization of inaccessible environments
- Facilitating task mastery through practice of dangerous or expensive tasks
- Improving the transfer of knowledge by situating learning in a realistic context
- Improving motivation through immersion
- Reducing cognitive load through integration of multiple information representations
- Facilitating exploration of complex knowledge bases
- Facilitating understanding of complex environments and systems.

Our virtual 3D networking lab is implemented using free, Java-based open source toolkit Open Wonderland for creating collaborative 3D virtual worlds [1]. It supports audio conferencing, desktop application sharing, and integration with external data sources. Open Wonderland provides a rich set of objects for creating environments, and supports shared software applications, such as word processors, web browsers, and document-presentation tools. For example, one or several users can draw on a virtual whiteboard and view PDF documents and presentations. A user, represented by an avatar, can communicate through the avatar to others in the virtual scene by using a headset or by the use of a dedicated chat window for text messages.

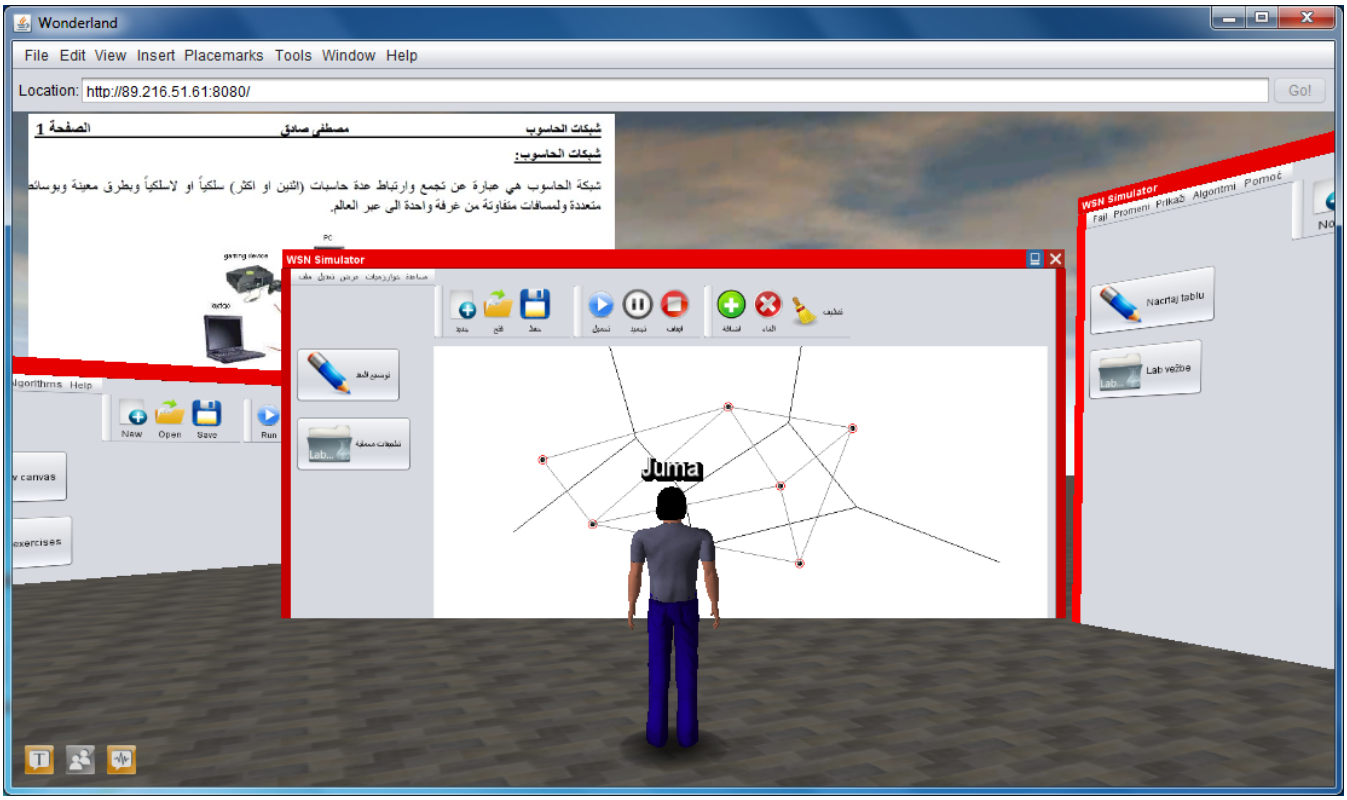

Figure. 1. WSN simulator in multi-lingual environment.

Within an Open Wonderland scene, students can communicate with audio, share live applications and documents. This toolkit is chosen over other similar ones for two principal reasons:

- It is completely extensible; developers and graphic artists can extend its functionality to create entirely new worlds and add new features to existing worlds. Application design is modular so that it can be relatively easily extended by developing plugins; this was the approach we followed in integrating our WSN simulator into Open Wonderland.
- It features tight integration of immersive, high-fidelity stereo audio. Participants in a scene can hear other people present in a virtual space at high sound quality. Since voices or other sounds become softer as you move away from them, Open Wonderland easily supports multiple, simultaneous conversations within the same virtual space, something not possible with current audio or video conferencing technology.

Creating multi-lingual versions of the simulator was fairly easy, given the fact that it was designed in Java, programming language that natively supports internationalization (I18n). The layout of 3D objects in a particular scene, including the simulator itself is defined beforehand by instructor (drag-and-drop of 3D models is supported). 3D scene in Wonderland can also contain lesson slides, animations, a whiteboard and other useful educational tools. Students join the scene in a scheduled time; Figure 1 illustrates a typical classroom session in which students run our simulator in Arab language, but can also practice running it in English and Serbian languages.

VI. Conclusions

Despite major efforts to fulfill the need for integrating simulators in education, there is still a great need for an environment that can better support teaching and learning tailored to specific needs of students. Preliminary and informal evaluation and feedback received from Arab students are encouraging and should help further development of our internationalized 3D network classroom.

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