Are the Curricula Able to Follow the Development Trends in Broadband Data Communications?

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Abstract – **The aim of the present paper is to introduce some specific problems of laboratory education at a technical university and their solution. The main area of interest relates to keeping the students' hands-on laboratory experience up-to-date. We focus on how quickly the new curricula of laboratory exercises can react to the new trends in various technologies, in contrast to those of lectures that can be easily updated continuously. We describe the way we most usually use for innovation of laboratory education curricula, its advantages and disadvantages, and give a specific example of modernization – introduction of the most recent DSL technologies and implementation of optical networks.**

Index Terms – Laboratory education, Curricula innovation cycle, New technologies.

DATA TRANSMISSION

One of the subjects taught in our laboratories relates to the problems of data transmission. The changes of laboratory education must be always very close to the development of technology. New technologies have been successively introduced also in our laboratories.

Telephone modems belonged to the first data communication devices serving for interconnection of distant computers and workplaces using the existing telephone network. Transmission speeds were successively increasing, beginning at several hundreds of bits per second. Reconfiguration of the earliest types was possible only through changes to their circuitry. The typical representative of this generation was the V.21 modem.

Along with the growing demands for data transmission capacity and voice transmission in telephone networks, the quality of transmission paths was improving and new types of modems were emerging, using various modulation techniques and the maximum available bandwidth of the telephone channel, which eventually reached the transmission speeds up to 56kbps – at least in one direction (e.g. V.90 modem).

Together with digitization of the telephone network and introduction of ISDN, new generation of digital data transmission devices appeared, enabling transmission speeds given by multiples of 64kbps through joint ISDN channels. The major disadvantage of this system was the connection price, which was also multiplied. However, this technology allowed the demonstration of video telephony and videoconferencing in education, being actually a step towards distance education.

The telephone modems were using quite narrow frequency band corresponding to the voice channel, offering only low transmission speeds. Their successors exploit the physical properties of cabling (subscriber line) much better, using the bandwidth of several MHz – ADSL or ADSL 2+ modems, shifting the available transmission rates to tens of Mbps [5].

Thanks to the fact that the recent generations of modems may be configured through a web interface [6], [7] and taking into account the progressive penetration of Internet connections in the households, it is now possible to prepare laboratory exercises that students can perform remotely, from home. This was one of the reasons for innovation of our laboratory workplaces with modems supporting remote management.

Using this approach it is possible to join the e-learning trend not only in lectures (where it is already quite common) but also in laboratory exercises. Students get the chance to measure and evaluate the tasks dealing with modem configuration and its influence on transmission parameters almost whenever, being not limited by the fixed length of the classes.

The full introduction of e-learning, however, could prevent the students from getting a hands-on experience with real devices and their physical appearance – they might even not be able to use the measuring apparatus.

To avoid this, we prepared also some exercises focused on physical connecting of the measured devices and on measurements of the transmission media. Students make personal experience with ADSL and ADSL 2+ modems; by using attenuation elements and connecting other line sections they can observe the influence on transmission parameters or measure optical transmission paths (as described below).

Another advantage of remotely passed part of laboratory exercises is that there is much more time for students who attend the presence part – they can be answered more questions or explained the relevant problems concerning the respective technology in more details.

The objective for the future is to find the optimum balance between distance and presence part of education that would bring the maximum benefit for students. For this reason we are planning a survey after finishing the semester, in which student will get a chance to comment our approach to education and provide their suggestions how the education could become more attractive.

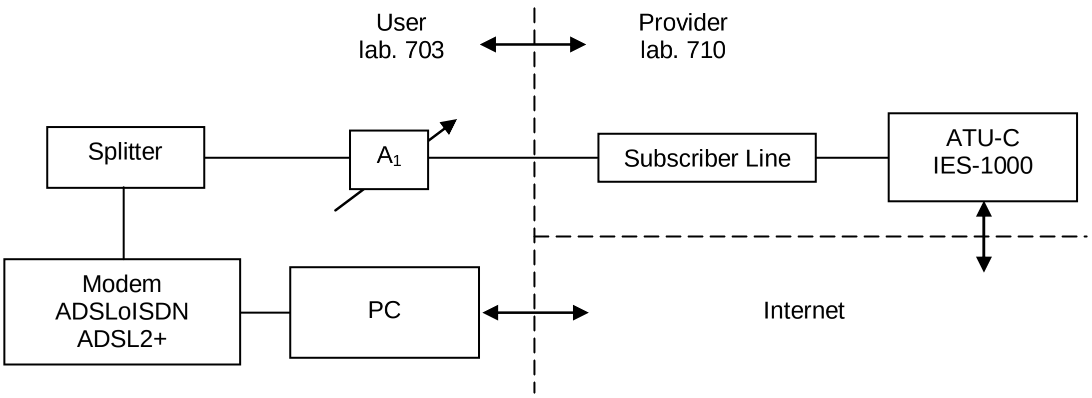

FIGURE 1
LABORATORY SET FOR ADSL MEASUREMENT. ATTENUATION ELEMENT (A1).

OPTICAL NETWORKS

In recent years it has been suggested that the most perspective way for increasing the transmission rates in telecommunication networks is the employment of optical systems. Data is transmitted in optical domain inside optical fibers that offer huge transmission bandwidth, very low attenuation, perfect electromagnetic compatibility or very small dimensions of optical cables [1].

The optical system components, e.g. optical fibers, should be thoroughly studied because of their present and future use, but also carefully lectured in order to raise new telecommunication engineers who will be able to design and implement optical networks. For these purposes they will need both theoretical and practical experiences with optical technologies.

We realized that in most cases, education is strictly focused on theoretical physical background of optical systems. Students are aware of useful and adverse physical effects influencing the propagation itself, but as mentioned before, mostly on theoretical level.

We believe that this disproportionate use of one teaching type leads to inefficiency. Theoretical and practical parts of education need to be balanced to give the best results. Students should be able to verify their knowledge within practical lessons. Despite that, the present trend is slightly different. E-learning has been paid much attention [2] and it is spreading into all types of education. However, we think that in the technical field, this approach alone is insufficient and real practical experiences are vital. We are supported in this opinion by the fact that students are unable to recognize basic optical components and their real performance.

One way to introduce some more practical knowledge is the use of simulation tools, which are presently very sophisticated, allowing implementation, simulation and evaluation of complex optical systems. Nevertheless, the real practical experience is achievable with real optical systems that comprise of basic optical elements. As for the electrical domain, the best optical engineers need to know the basic components, their structure, form of packaging, and mainly the real practical influence of optical environment on signal propagation.

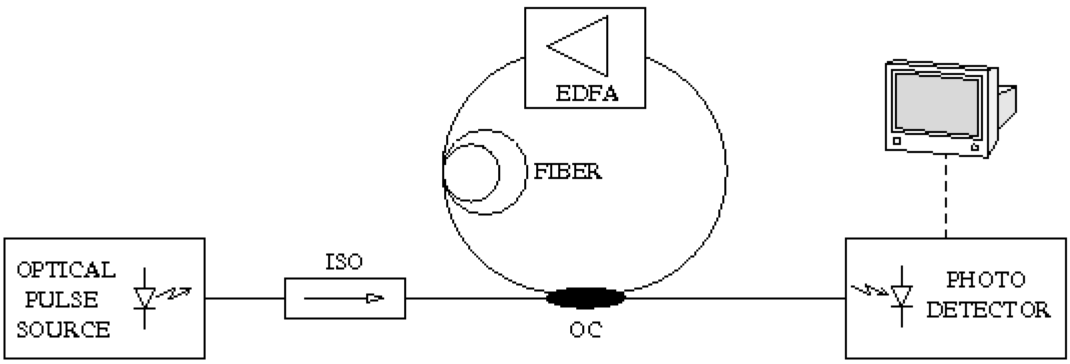

FIGURE 2
LABORATORY SET FOR LONG-HAUL OPTICAL TRANSMISSION SIMULATION.
ISO – OPTICAL ISOLATOR, OC – OPTICAL COUPLER, EDFA – ERBIUM-DOPED FIBER AMPLIFIER

We want to give our students opportunity to explore the physical properties of each component and to learn how to handle them when building up new configurations. Because the signal propagation is one of the key concerns of telecommunication engineering, we suggest coming up with a laboratory set that will simulate the long-haul optical transmission. The configuration scheme is known as recirculating loop [3].

The principle of operation is as follows. The source of optical pulses provides the system with a probe signal. This optical signal propagates through an optical isolator. The isolator ensures that no optical beam is traveling backwards into the pulse source, which could lead to a damage of the internal laser diode. Behind the isolator, the signal is split inside an optical coupler according to its coupling ratio into two replicas. One of these replicas will propagate straightforwardly into the photodetector and its time dependent power characteristics will be displayed by the oscilloscope. The second replica propagates inside the recirculating loop consisting of an erbium-doped optical amplifier and an optical fiber. The amplifier acts as a regenerator of optical signal power, thus representing the repeaters in real systems. After the amplification, the pulse is split inside of the coupler again and the whole situation repeats. As the pulses propagate in the loop, they are influenced by the amplification and by the optical effects such as attenuation, chromatic and waveguide dispersion, and also nonlinear effects [4] originating from the physical properties of the fiber. Final shapes of output pulses are distance-traveled dependent, so each time the pulse propagates through the loop, its temporal shape and power characteristics will change. The overall evolution of the pulses shape is recorded on the display of an oscilloscope.

Students will discuss the portion of influence of each optical effect and will have a chance to compare real results with simulated ones. They will be also able to recognize each of the optical components and study their real properties by measuring their transmission characteristics.

CONCLUSION

We have prepared an innovated system for education of a subject dealing with data transmission and optical networks. We tried to balance the ration of traditional face-to-face education (i.e. some lectures), e-learning approach (some lectures and remotely controlled laboratory workplaces) and intensive laboratory education (less students, more personal attention). After finishing the first run we are going to make a questionnaire-based survey to obtain feedback from our students.

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