

## TOWARD SPECIALIZED UNDERGRADUATE TELECOMMUNICATION ENGINEERING EDUCATION IN THE US

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In ancient times, unless somebody was prepared to travel, man could only communicate as far as he could shout. Methods were then developed to enable communications to extend over longer distances, using trumpets, beacon fire, flags, etc. It was not until the inauguration of telegraphy (by W. Cooke and C. Wheatstone in England in 1839, and by S. Morse in the US in 1844) and telephony (by A. G. Bell in 1876), that electricity was utilized to facilitate commercial telecommunication service [1]–[2]. Then, for nearly 100 years, telecommunications was mainly about telephony and telegraphy and was based almost entirely on electrical engineering methods. From audio to radio signals, electro-mechanic to electronic technologies, analog to digital systems, and electronic to photonic devices; telecommunications has witnessed tremendous progress on numerous fronts. In terms of services and applications, telecommunications evolved in recent years to embrace cyber space, entertainment, and electronic commerce and business.

Telecommunications made impressive inroads toward a revolution of its own and has indeed changed the way we live our lives. Past and continuing advances in this field calls for special attention to Telecommunication Engineering (TE) education [3]–[4]. For a long time, TE education has been mostly considered as part of the electrical engineering (EE) education discipline. This was consistent with the beginnings of the field and how it evolved for quite some time. For the past two decades, however, the definition of Telecommunication has been changing rapidly. Fundamental advances in packet switching and transport; convergence of telephone, computer, cable, and satellite networks; emergence of cellular telephony; secure data storage; text-based messaging; web-based applications; and peer-to-peer applications are just a few examples of the drivers behind this change. As a result, TE has been gaining the status of an independent engineering education discipline in many countries. Unlike EE programs with emphasis on communications, TE programs supplement the study of communication theory, signal processing, and electromagnetics with core courses in network science and engineering [5]. This trend has not been fully echoed yet in the US education system.

Until the 1990s, the closest academic courses to the Telecom industry needs in the US were certain EE and general system optimization courses (operation research). The concepts of a telephone network, transmission systems, switching systems, and later on, data networks, optical networks, and wireless networks, were mostly absent from curricula. Graduates of other engineering and scientific disciplines had to go through extensive technical training in Telecom companies to

understand these concepts. As a result, it would take many years for a new engineer, whether with an undergraduate or graduate degree, to have a proper understanding of telecommunication networks. During the 1990s, specialized telecommunication education attracted some interest due to a burst of industry growth. This led to the development of certain technology, mass media, and management education programs [6]. Almost no engineering programs were launched, however.

There are a number of reasons why Telecommunication Engineering (TE) education has been conveniently embedded within the Electrical Engineering (EE) education discipline in US Universities in particular [3]–[4]:

1) Engineering education in the US focuses mainly on fundamental disciplines, such as electrical, computer, mechanical, civil, and chemical engineering. The philosophy underlying this arrangement is that undergraduate education needs to be broad enough to prepare students for several careers. However, engineering knowledge has expanded today to such a degree that it may be necessary to at least rethink or readjust core disciplines while realizing this philosophy. One example that attests to the need for rethinking, and the success of adopting changes, is the popularity of bio-medical engineering programs, which were established to address challenges that do not fit entirely within one of the traditional engineering disciplines

2) Before 1984, the Bell System was the owner of the US telecom industry and was the country's primary TE educator. It had established technical education center(s) for undergraduate-type education, and Bell Labs was effectively the nation's telecommunications engineering graduate school. Semester-based TE courses were taught in the Bell System, and there was little need for a nationwide university-based TE education. Despite the end of the Bell System in 1984, the momentum of its education regime kept things going for some time.

3) The breadth of the scope of topics involved in TE education may also have been an issue. A significant component of mathematical, physical, and computer sciences is involved in TE education. Components of electrical and computer engineering are required before core TE topics are introduced. Therefore, some envision that it is not easy to map all these components and others into a standard four-year Bachelor's program. The fact is, however, that an understanding of the academic ingredients that are really required to make up a TE program, versus those that are not, is necessary to strike the right curricular balance. Unfortunately, the confinement of TE education within industrial premises for decades, apart

from academic frameworks, made it difficult for some to fully realize this field from a pedagogical perspective.

In the 1990s and throughout the 2000s, some schools graduated engineers with an acceptable level of TE/network knowledge. This was not due to the existence of organized formal education programs, but rather to dedicated efforts of individual faculty who happened to have interest in some aspects of the field. Such efforts are often hindered by lack of resources, as students typically have access only to classes and laboratory equipment that are directly related to a faculty or a research lab's focus. They do not have a chance to experience a comprehensive set of curricula and equipment dedicated to providing a complete view of telecommunication engineering principles. Also, almost all of these TE-related education activities take place at graduate programs of study, and not at the Bachelor's level. This has created a problematic situation. In any engineering discipline, undergraduate study provides four years of basic and broad education of the discipline, which paves the way for a deeper and more focused study of certain principles at the graduate level. In the case of telecommunication engineering, there is no such basic undergraduate education to start with. As a result, the Telecom industry has to hire university graduates who lack complete, or even satisfactory, academic preparation.

According to hiring managers in the Telecom industry, recruits from undergraduate programs are very expensive to prepare for industry positions. On the other hand, recruits from graduate programs had to plunge into narrow focus areas as part of their advanced studies without first having had the opportunity to appreciate the overall telecommunications landscape. Hence, new hires of all kinds have attained theoretical knowledge of some telecom function or a related piece of equipment, at best, without necessarily understanding how it relates to telecommunication networks in general. This state of affairs would be analogous to an electrical or computer engineering graduate who is educated in the details and intricacies of memory chips, but is never taught what a micro-processor is or for that matter how memory chips fit into, and are used as fundamental components of, a computer system.

The U.S. Telecom industry experienced tremendous growth in the late 1990s, but plunged into a sharp downturn by the beginning of the 21st century. During growth, the industry fulfilled its hiring needs by relying on the Bell System expertise, which was still largely available, and also on other professionals, many of whom were international telecommunication engineers. Today, the industry is still going through a post-bubble era, which is exacerbated by a global economic crisis. Therefore, many may argue against the need for TE education programs in the United States at this point in time. This argument, however, is shortsighted. In fact, the telecommunications field never ceased to grow in applications, services, bandwidth needs, users, and network types/scales. It is only a matter of time before the Telecom industry will start to bounce back economically. Most importantly, with the rate of innovative growth over the last two decades, the technical foundations of telecommunications engineering have undergone huge paradigm shifts. Hence, it is going to be harder than ever for the US to advance, much less lead, in this area of engineering without having a robust academic structure to educate and prepare future telecommunication engineers.

Today, there is a substantial void in the US TE education arena. On one hand, the breadth of the technical scope of modern telecommunications makes it difficult for the industry to self-educate its engineers, or to actually afford the kind of investment the Bell System used to bear in this regard. In fact, many telecommunication companies have disbanded in-house

training and depend today on outside resources. On the other hand, Telecommunication Engineering (TE) is not recognized as a field of university-based education. Only a couple of programs exist in the US, but they are not accredited based on specialized TE accreditation criteria<sup>1</sup>. The absence of such criteria is problematic and discourages other universities from investing in this area of engineering education.

The US society, economy, and national security are increasingly dependent on scientific and technological innovations [7]. Having a new generation of well educated graduates who are ready to lead technological advancement through the 21st century is a critical requirement in all areas of engineering knowledge. In this context, ushering in Telecommunication Engineering education programs across the nation is vital for filling a gap that may cost a lot, and will undermine US leadership, if not attended to now.

For the IEEE Communications Society (ComSoc), telecommunication engineering education is a strategic need for our global community. Therefore, the ComSoc Education Board (EB) launched an effort in 2010, and throughout 2011, to recognize and promote Telecommunication Engineering (TE) as an education discipline in its own right in US universities. A Task Force (Work Group) has been formed in this regard to discuss this subject, determine the best possible strategy to serve this cause, propose curricular components and/or program criteria, and make recommendations/suggestions to the Accreditation Board for Engineering and Technology (ABET). The ComSoc Task Force on Telecommunication Engineering Education (TF-TEE) in the US is led by Tarek El-Bawab as Chair and is composed of the authors of this article. We believe that TE university programs are needed in the US academic education system. These programs would help attract more American citizens to engineering study, attract international students who come to study in the US, and would secure much needed support for our industry and economy. We have already launched an effort to promote this cause with IEEE Education Activities along with communities and constituencies who have a stake thereto.

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<sup>1</sup> Criteria exist only to accredit telecommunication engineering technology programs in the US.