Telematics: A Distinctive Discipline

Carlos Delgado Kloos  Arturo Azcorra Saloña
Dep. Ingeniería Telemática, Universidad Carlos III de Madrid
www.it.uc3m.es

Abstract

With the advance of knowledge, new disciplines are successively identified. Computer Science has its roots in Babbage and others, but was identified as a separate discipline during the last century, when there was enough body of knowledge and when there was a need to have specialists mastering the knowledge developed around computers and computing. The thesis of this paper is the proposal of Telematics as a distinctive discipline, a discipline that shares a lot with Computer Science and with Electrical Engineering, but whose body of knowledge deserves being identified as such, since it is today already big enough and is expected to grow even more in future.

1. Introduction

When a new discipline arises, it shares many of the principles and techniques of its ancestor disciplines in a unique mix. When Computer Science was born, it shared many principles and techniques with both Mathematics and Physics, in particular, Electronics. On the one hand, computers are physical devices, originally electromechanical and later electronic. On the other hand, computing shares the abstraction and formality in reasoning and expression of Mathematics. This is why the discipline of Computer Science inherits from Mathematics theories of Logic and Algebra to treat the languages in a formal way (syntactically as well as semantically). And to study and understand the building blocks of the computers it is necessary to master the theories developed in electronics, in their analogue, but most notably in their digital part. But Computer or Computing Science, depending on the flavour you want to give to it, is more than Mathematics and Electronics. Computer Science has developed its own well-founded theories, theories for compiler construction, or for databases or operating systems, etc. as well as practices and uses.

The term Telematics was coined in a report requested in December 1976 by a French President [1]. In that visionary report, it was foreseen that the convergence of Computing and Communications was opening a new field of research that would lead to a distinctive discipline and a new business sector. Telematics studies Computing and Communications in equal terms, and, what is more important, their synergistic effect.

2. Computing and Communications coming together

After the initial analogue computer, the digital computer was a giant step as far as abstraction was concerned. Several issues were abstracted away from, which were introduced later as they were understood better. The first systems were sequential, monoprocessor and localized. Later came (pseudo-concurrent and) concurrent processing, multiprocessors, real-time computing, and distributed computing, successively introducing increasing complexity of reasoning and design. Concurrency and distribution introduced the concept of (synchronization and) communication in computing.

On the other hand, the roots of Telematics in modern telecommunications date back to telegraphy techniques, well before the electronic computer was developed and before radiocommunication or telephony existed. The transmission of symbolic digital information, the development of optimal source coding, the concept of message switching, the development of the first encryption systems for telecommunications, are all associated with the Telematics body of knowledge.

Telematic theory was then applied to computer communications, in order to allow first the remote location of mainframe peripheral devices, and later full interactive remote access using Cathode Ray Tube terminals.

This first step of computer conversation marked a relevant milestone in the Telematic discipline: the development of communication protocols and protocol architectures. Digital communications, based on communication protocols, have since been coping with an ever larger fraction of the total modern communication spectrum. First applied to the control and management plans of telecomm-
munication systems, nowadays almost every new telecommunication system developed is digital.

The progressive digitalization of telecommunication systems and their abstraction in terms of communication services have inverted the entropic tendency towards a distinct telecommunication technology and infrastructure for each telecom functionality offered to the user. Digitalization and abstractions have led to the source-coding of any type of information, its compression and packetization in order that it be transported over increasingly integrated networks technologies and infrastructures. The logical separation of the control plane and the user plane allows for an independent evolution of both the technology and the infrastructure that controls and transports the user information.

Due to this digitalization and integration of services, telecommunication systems rely so much on computing, their components are basically computers.

3. Computing and Communications evolving together

Both (digital) computation and digital communication are founded on the same concept: the discretization of information, mostly based on the binary digit for technological reasons. The concept of computation and computability, which can traced back to Turing and contemporaries, and Shannons mathematical theory of communication were both formulated in the first half of the 20th century.

Seen at the microlevel, computation and communication cannot be distinguished. Signal changes are transformed and combined through devices to changes at output signals, thus performing computation (the value at the output differs from the input values) and communication at the same time (input and output signals are not at the same location).

At the macroscopic level, computation and communication cannot be understood nowadays one without the other. Here are some examples:

With the client-server model, where programs reside in servers, but are executed in clients elsewhere, computation and communication are mixed and intermingled. Also the web, first “just” a distributed publishing platform based on two concepts, http and html, a communication protocol and a mark-up language, soon converted into a platform for distributed computing. This trend is seen even further in paradigms such as P2P (peer-to-peer computing, or should we stress peer-to-peer networking?) or grid computing. Grids aim at exploiting synergies that result from the ability to share and aggregate distributed computational capabilities and deliver them as services. The grid gives rise to models like utility computing, which enables the leasing of computing resources by customers on an on-demand-basis based on QoS requirements.

Another example is that of mobile terminals, minute devices for communication and computation. Computation is not only performed in so-called computers, but increasingiy also in embedded systems and a multiplicity of diverse devices. If the 70’s and 80’s were the decades of the isolated mainframe (one computer, many persons), and the 90’s and 00’s the period of the more and more connected personal computer (one computer, one person), we are entering the era of ubiquitous computing [3] (many computers, one person), of multiple computing devices that cannot be conceived of without being connected with one another through networks, be they wired or wireless, with infrastructure or ad-hoc. The tradeoff will often arise, whether to recompute a piece of information or to get it from somewhere else. The network of interconnected devices will grow so much that new ways of handling, managing and configuring these networks will be needed. Autonomic computing [4], planetary computing or recovery-oriented computing are initiatives in this direction.

The two pillars on which Telematics is based, computation and communication, are reaching their physical limits. The insulators in CMOS transistors cannot get much smaller or the insulating layers will stop insulating (at around 6 atoms thick). This is a limit to computation which might happen before 2010 or 2012, if we follow Moore’s law of semiconductors. On the communications side, in optical fiber, we use ten thousand or so photons to represent a bit. There is a Moore’s law for fiber, too, and we will soon run out of photons. Maybe before 2010. These limitations will imply that computation will become necessarily more distributed.

Quantum mechanical effects will become important in just a few years! Then the classical bit will be replaced by the qubit, the quantum bit, that results from removing the approximation that the elements of information are independently manipulable [5]. Quantum computation and communication will then give rise to a new kind of Telematics. But, that’s another story . . .

4. New skills needed

The identification of separate disciplines has an effect in education and labour. Already some groups when identifying the skills for future engineers have seen the need for graduates with a Telematics profile. For instance, the Career Space initiative stresses the fact [2] that “the majority of graduates increasingly need a combined qualification from both cultures: engineering and informatics.” One can also read, that “the teaching of ICT curricula in universities has evolved from the development of natural and structural sciences. One main route comes from electri-
cal engineering deriving from physics, and the other from informatics/computer science deriving from mathematics. Historically these two routes evolved in different departments/faculties and they developed different approaches, methodologies and cultures, even when tackling similar problems. It is not surprising that the aims and content of ICT related curricula coming from such different origins are also different."

It is as important to manage the internals of the computer as it is to manage its surroundings, i.e. the network. The study can go hand in hand: the study of computer architecture can go with the study of communication architecture or communication networks, the study of data and knowledge bases can go with the study of storage area networks, the study of operating systems can go with the study of network management systems, the study compilers and interpreters can go with the study of coding techniques, etc. Furthermore, the basics of computing devices, nowadays, basically the microelectronic technologies, should be studied as well as the basics of wireless or wired communications.

The existing structure of universities and other education institutions is sometimes a barrier for the clear identification of new curricula, although in some countries interesting developments that move in this direction can be seen. The need for a distinctive curriculum in Telematics does not eliminate the need for the classical ones in Computer Science or Electrical Engineering, even if they evolve and include contents resulting from the synergy of computation and communication (such as Distributed Computer Science or Intelligent Networks, for example, in one or the other case).

5. Conclusion

As already stated, the term Telematics was coined, as Telematique, in a report in 1976, combining the words Telecommunication and Informatics. It has since then been used with such a general meaning in many countries such as France, Italy, Spain, The Netherlands. Also the EU had a research programme called Telematics. In other countries, such as Germany or USA, it is sometimes used with a more restrictive meaning, and occasionally refers to these technologies when just applied to the automotive sector. Interestingly enough the term Multimedia is also colloquially used to refer to the converging technologies.

ICT, Information and Communication Technologies is sometimes used to refer jointly to Computer Science (Information Processing or Informatics) and Telecommunications. The term is rather misleading, since, as already noted, both technologies are based on information. Computation and Communication Technologies, or just Information Technologies, would be more appropriate. What-ever the name chosen, we feel that the convergence of both technologies entitles it to be called a discipline on its own. A new discipline that is more than the sum of their ancestor disciplines, but has to take the best practices from them, where the Church-Turing thesis is studied as a basis as well as Shannon’s mathematical theory of communication. Such a discipline should be taught at educational institutes and universities, be it in Computer Science schools, Electrical Engineering schools, combined schools, or newly created ones.

6. References


