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# SPECIAL ISSUE
# Reliability and security of information

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## 1. INTRODUCTION

The infrastructure of our information and communication networks is quickly developing. All over the world, researchers are successfully working on higher capacity data transmission and on connectivity enhancement. Traditional limitations of time, space and quantity are gradually loosing their grip on the availability and accessibility of information and communication. What are the consequences for our ways of assessing the reliability of information and for safeguarding the security of communication? In this editorial, we first draw an outline of the attempts to enhance the capacity for data transmission (for internet, e-services, video streaming, etc.), with a special focus on recent developments towards ultrafast all-optical communication. Subsequently, we will draw attention to the possible consequences of the implied dramatic increases in connectivity and the availability of information. Finally, we introduce the papers that were especially prepared for this special issue in order to deal with some of the issues involved.

## 2. DEVELOPMENTS IN INFRASTRUCTURE

Easy and fast network access is being realized by implementing high-capacity optical connections and flexible access to and in home networks. Figure 1 shows a schematic of the network infrastructure. The environments of the subscribers are also visualized in this sketch, indicating that the use of a variety of wireless networks is rapidly growing. Examples are wireless local area networks, bluetooth and mobile telephony. The growth of both of these wireless networks and fibre-to-the-home connections will dramatically increase the need for more capacity in the wired part of the network. During the last decade, a vast amount of optical fibre cable has been installed in communication networks all over the world and even today new cables are laid at an astonishing rate. Especially the increasing number of fibre-to-the-home connections will put enormous pressure on the capacity of the upper hierarchy of long-distance networks. Figure 2 shows the expected increase of network traffic. Note that most of the growth will be due to the exponentially expanding internet traffic. Without doubt, light has become the dominant medium for transmitting information. In fact, photonics is considered to be the most important key technology of this century, to such an extent that one might refer to the present century as that of the photon, just like last century was that of the electron.

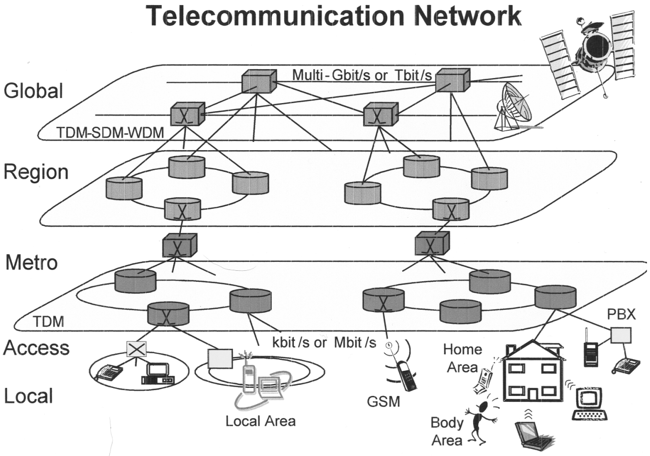


**Figure 1** Schematic of the telecommunication network hierarchy. The various hierarchic levels are indicated. The cylindrical or rectangular boxes indicate the nodes. The congestion threat reported in this paper becomes more serious the higher one gets in the hierarchy.

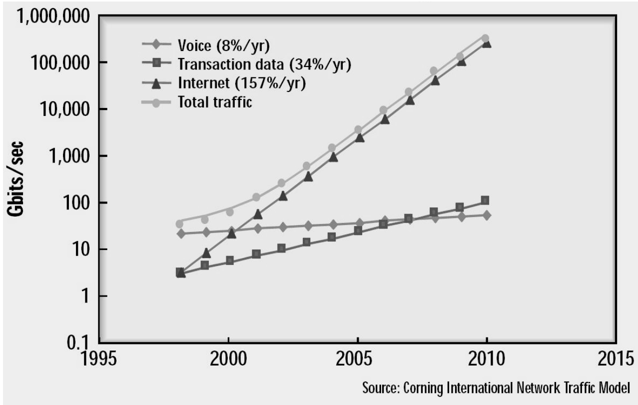


**Figure 2** Network traffic growth projections (D.B. Keck: http://www.corning.com/docs/opticalfiber/r3461.pdf)

A crucial element in every network is the communication node, a facility in which information packages are received, inspected, buffered, labelled, redistributed and sent out again. Several nodes can be seen in Figure1. They are present in every network, and the demand for higher capacity and throughput will manifest itself first at the higher levels of the network hierarchy. Presently, these nodes are fully electronically operating. This means that incoming optical signals are converted into electronic signals, then electronically processed, i.e. identified, buffered and labelled, and finally converted back into optical signals and transmitted to the user or to a next node. The processing speed of one conventional electronically operating node is generally 1 Gbit/s, i.e. 109 data bits per second. This may seem incredibly fast, but one should realize that the transmission capacity of a single ordinary glass fibre transmission cable is generally more than 100 Tbit/s, more than 100,000 times higher capacity than one electronic node. This means that if the fibre links in a telecommunication network are used to their full potential, the communication nodes will become bottlenecks for fast processing and rerouting of the data packages. Congestion of the whole network will unavoidably happen, not to speak of the danger of data packages getting lost forever. The solution to this problem is to develop a sufficiently fast alternative technology for data processing, preferably at teraherz speed, on the basis of which new types of nodes can be constructed. The potential maximum bit rate for a telecommunication link is set by the above-mentioned optical bit transmission capacity of the glass fibre. In order to deal with this enormous capacity in the node and to avoid the previously mentioned congestion problem, it would be very logical to stay in the optical domain all the way and hence make the network nodes optical as well. This means that a basic ultrafast optical device technology should be developed which will make the realization of all types of functionalities possible, such as, buffering of data, header recognition, switching of packages and regeneration of pulses. These devices must allow digital processing functions to be performed on data signals while "on the fly" and never leaving the optical domain, see Cotter et al. (1999).

The engineers working on these devices find themselves in a situation comparable to that of the microelectronical challenge for electronic information processing in the1960s. Knowing the basic components needed for realizing the necessary functionalities, the challenge then was to realize microelectronical building blocks that could be integrated onto one single electronic chip device. We all realize now that this development led to a revolution in electronic devices, ultimately bringing fast electronical equipment within reach of the general public; the personal computer being the most remarkable example. The ambition of Photonics is to make all of this much faster, not only in transmission speeds but also in bit manipulations per second. At the same time, the photonic circuits should become less power consuming in order to create opportunities for personal applications in portable versatile communication devices or for personal electronic health care. Thus, light will influence our way of living to an extent we never could have imagined just a few decades ago. Photonics will play a crucial role – often the central role – in our daily life, notably in the ways we communicate and in the tools we use to explore the frontiers of science.

To realize the photonic ambition, one needs to find optical alternatives for each electronic building block, such as flips flops, gates, buffers, memories, shift registers, transistors etc. The information in electronics is normally present in the form of binary units or bits, simply on or off. This is less restrictive in the photonics domain, since here the possibility of different parallel wavelengths in addition to the binary information handling introduces per wavelength channel an enormous flexibility in the way the information is digitized, which introduces a lot more design possibilities.

One important scientific result that has already been confirmed by several experiments is the possibility in commercially available semiconductor amplifiers, under suitable conditions, to produce a sizeable phase shift with an optical control pump pulse during an ultra-short time of ~500 femtosecond. (Dorren et al., 2003; Dorren et al., 2004; Yang et al., 2004). These results show that ultrafast all-optical switching of 200 femtosecond pulses at 1 Tbit/s rate is possible. Also, all-optical memories and shift registers on the basis of bulk components have been demonstrated (Hill et al., 2001; Zhang et al., 2004). The next step is to achieve the high bit rates aimed for. In order to do so the required energies of the pulses for nonlinear effects must be reduced further in order to keep the heat dissipation within acceptable limits. This is especially true for the integrated optical circuits that will ultimately be fabricated. Here, the density of functionalities may be so high that heat dissipation becomes a critical issue. Very promising progress with respect to decreasing the power budget comes from semiconductor quantum dot materials. Switching capabilities with optical pulses of less than 6 femtojoule were demonstrated by Prasanth et al. (2004). If this could be realized at 1 Tbit/s bit rate, the power consumption per switch would amount to 60 mW, an amount that is acceptable but should be reduced further by a factor of ten in high-density integrated circuits. Finally, a recent achievement in integration technology should be mentioned, namely the fabrication of a fast low-power flip-flop optical memory based on coupled micro-ring lasers (Hill et al., 2004). This single-bit optical chip operates on a frequency of 50 GHz and 5.5 femtojoule switching energy. These numbers can still be improved considerably by optimizing the design.

In short, new technology is developed for all-optical ultrafast signal processing and handling. This will lead to all-optical ultrafast telecommunication nodes that can handle the full potential of the existing optical fiber transmission capacity. All-optical building blocks have been realized in concept and the first integrated device versions will soon be fabricated. This development will make telecommunication networks in general and the Internet in particular orders of magnitude faster.

## 3. RELIABILITY AND SECURITY

The introduction of the Internet has brought about considerable changes in the ways in which people communicate and disseminate and gather information. Remarkably, people's ways of assessing reliability of information and safeguarding the security of communication are still, to a high degree, geared to traditional media. They relate to the – often institutionally embedded – signs of authority of the sources and intermediaries and to the recognisability of the details of the process of the transactions involved (Vedder, Wachbroit, 2003, Vedder, 2005). With the growing speed of the information and communication networks two characteristics of the Internet are further enlarged. First, assessing the true nature of sources and intermediaries of information becomes even more difficult. Second, as the technologies involved become more sophisticated and complicated, the processes of interaction become less transparent. All of this diminishes the possibilities of assessing the trustworthiness of partners in communication and of information content providers, and of assessing the validity and reliability of information and of ensuring the security of transactions.

In this special issue, we try to obtain a more sophisticated understanding of the backgrounds of this problem and to suggest some starting points for solutions. Two papers illuminate psychological and epistemological issues. In 'Perception and interpretation of internet information: accessibility, validity and trust,' Don Bouwhuis explores some elementary psychological features of human perception of physical objects that complicate the interpretation of online information and communication. He points out that the possibilities of understanding and trust in a digital context are inherently restricted because of the differences between the perception and interpretation of the physical world and the perception and interpretation of electronic entities. Erkki Patokorpi and Kai Kimppa map out the intricate pattern of contextual conditions that affect building trust online. Focusing on trust building in the context of electronic commerce, they argue that different combinations of the contextual conditions of trust building will result in different types of trust. The authors of the remaining papers suggest solutions and remedies. In 'An approach to facilitating communication of expert arguments through visualization,' David LePoire proposes a new expedient for the assessment of experts' judgements in online communication, by introducing the idea of the visualization of arguments. Greet Vanden Berghe, Patrick de Causmaecker, Martin Meganck and Stijn Bernaer indicate promising new options by describing and evaluating a way of building trust by prominent involvement of software agents. They concentrate on the ways in which technology can gain trust from the users and on ways in which trust as an attitude of people towards each other can be transferred to technology. Finally, Maurice Schellekens and Corien Prins explore the (limited) possibilities of introducing the law in order to deal with reliability problems.

In this special issue, we do not in the least pretend to cover the complete spectrum of all of the questions and possible answers involved. We merely hope that this issue will help to clarify the problems and to kindle further debate.

## ACKNOWLEDGMENTS

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