Chapter 2
Ethical Aspects of Research in Ultrafast Communication

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Abstract This chapter summarizes the reflections of a scientist active in optical communication about the need of ethical considerations in technological research. An optimistic definition of ethics, being the art to make good use of technology, is proposed that emphasizes the necessarily involvement of not only technologists but also experts in humanity. The paper then reviews briefly the research activities of a Dutch national consortium where the author had been involved. This mainly academic research dealt with advanced approaches for ultrafast communication. In the next section an assessment is given of the potential impact of the technological results on society. In order to emphasize the positive aspects and counteract the negative ones, three steps are proposed: (i) create conditions for a dialogue between experts in ethics and technology; (ii) work out scenarios for the introduction of new techniques in society; (iii) anticipate opportunities and threats. Finally the conclusions are presented.

Keywords Optical communication · Ethics in technology · Future scenario · Education · Technology assessment

2.1 Introduction

Over the last decade there has been an increasing interest in ethics in a number of fields not traditionally associated with ethics, such as business, medicine, publishing, science, and engineering. In the Netherlands an initiative started as part of a national research project administrated by the Dutch Foundation for Technology (STW).[1] In this project ethics-related activities were carried out parallel to the technological research to which it applied, and interaction between the technological

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[1] Towards Ultrafast Communication, Freeband Kennisimpuls (Dutch for “knowledge impulse”). Financed by the Dutch ministries of EZ and OCenW and coordinated by Prof. D. Lenstra, VUA.

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and ethical parts was stimulated.[2] At the end of the project two symposia were organized[3] where researchers from both parts presented their findings. The present paper is based on a presentation given at one of the symposia.[4] Being involved in applied science and—more specifically—being a project leader of the above mentioned national research project, I intend to summarize my reflections on the need of ethical components in technological research. The STW project is called Towards Ultrafast Communication, and it involved three Dutch universities: The Technical University of Eindhoven (TU/e), the University of Twente (UT), and the Free University Amsterdam (VUA).

In order to start one should explain what ethics could mean in the context of technology. Already in Greek philosophy ethics was studied and brought in connection with what is specific to human beings.[5] In the Aristotelian vision this is the capacity to guide oneself by using reason. In modern times the same connection is made, as this capacity is seen as the foundation of human dignity, and it has led to the conceptual foundation of human rights.[6] One therefore could say that a certain behavior or choice is ethical if it is in accordance with reason and thereby in accordance with the dignity of human nature. An optimistic definition is given by J.L. Lorda: "Ethics is the art to live well".[7] Focusing on our specific field of interest one could say that ethics in connection with technology is *the art to make good use of technology.*

In this definition the term "technology" can be taken as the concrete apparatus, a car, for example, or as a certain knowledge and infrastructure of apparatuses and equipment as expressed in terms like "nanotechnology". In the latter meaning, the design and development of new products and the choices made during development should also be considered as an important part of ethics of technology. The qualification "good use" should be taken in the widest range of meaning. The use of technology should objectively be good, that means all technical aspects should be optimized including related issues, e.g., the responsible use of resources and possible waste. But the goodness should also appear in the subject, that is, in the human being who makes use of the technology. Only if technology is used reasonably—respecting commonly accepted human values, i.e. according to human dignity—can one speak of ethical behavior.

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[2] For more details see A.H. Vedder and D. Lenstra, "Reliability and Security of Information". J. Inform. Commun. Ethics Soc. 4(1), 3–6 (2006).

[3] The two symposia were held at NWO, The Hague on 14-2-2007 and 20-4-2007 respectively.

[4] A. Driessen, "*Is er een behoefte aan een ethische component bij technologie onderzoek?*" A lecture presented at the NWO symposium on Moral Technology Assessments, The Hague, 20-4-2007.

[5] See, e.g., Aristotle, Eudemian Ethics.

[6] Universal Declaration of Human Rights, UN. 10-12-1948, Article 1, "All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood." See http://www.un.org/Overview/rights.html.

[7] J.L. Lorda, *Moraal de kunst van het leven*, De Boog, Amsterdam 2006.

In the above definition ethics is defined as an art, meaning that two aspects should be considered: knowledge and skills. These two aspects are not necessarily found in a single person. Focusing, for example, on the art to play a violin one finds that excellent theoretical knowledge of a violin neither implies that you are a virtuoso nor a composer, and the same is true vice-versa. Applying this paradigm to ethics of technology one could state that the engineer or scientist is not able to deal on his own with all aspects of the art to make good use of technology. He misses the expertise to guide the subject, the human being, in his acting ethically. For this experts in humanity are needed who scientifically study human behavior and the values related to human dignity.

The paper is organized as follows: after the brief introduction with a tentative definition of ethics in the field of technology, a sketch of the field in which the technological research project and ethics apply is presented. In order to illustrate the work performed in the four years of the project, two examples of research highlights are given. Thereafter an assessment is made of the consequences of ultrafast communication on society. It is obvious that besides the positive aspects there are also quite a number of negatives that can be distinguished. In order to emphasize the positive and counteract the negative, three steps are proposed. Finally the conclusions are presented.

2.2 Technical Aspects of Ultrafast Communication

The national research project Towards Ultrafast Communication deals with transmission of data with speed beyond 100 Gbit/s or 0.1 Tbit/s. This speed is still slow when compared to the capacity of a single optical fiber, which exceeds 10 Tbit/s. It is high, however, if one realizes that in this way the data of 3 DVDs can be transmitted within a second. Comparing this speed to what is called today a broadband connection of 1–10 Mbit/s one may put question marks about the practical applications. Recent predictions, however, assume the introduction of 1 Gbit/s per user already within a decade (see Table 2.1).[8] In this case, at the nodes of the access networks data in the Tbit/s range would have to be routed.[9] Currently available electronic equipment is far from being able to handle such high bitrates. Moreover, even if they were able, power consumption would be a serious problem. Optical techniques would offer attractive solutions. At the TU/e a significant breakthrough was made in 2004 by realizing an all-optical switching element, a “flip-flop”, with a switching time below 18 ps (see Fig. 2.1).[10] After that, Dorren et al. constructed devices with

[8] R.E. Wagner, J.R. Igel, R. Whitman, M.D. Vaughn, A.B. Ruffin and S. Bickham, “Fiber-Based Broadband-Access Deployment in the United States”, J. Lightw. Techn. 24, 4256–4539 (2006).

[9] A.M.J. Koonen, “Fiber to the Home/ Fiber to the Premises: What, Where, and When?”, Proc. IEEE, 94, 911–934 (2006).

[10] M.T. Hill, H.J.S. Dorren, T. de Vries, X.J.M. Leijtens, J.H. den Besten, B. Smalbrugge, Y.S. Oei, H. Binsma, G.D. Khoe and M.K. Smit, “A Fast Low-Power Optical Memory Based on Coupled Micro-Ring Lasers”, Nature 432, 206–209 (2004).

Table 2.1 Projection of user demand for bandwidth, showing a Gbit/s target within a decade[8]

Technology	Per user	Start	50%	
Phone modems	<100 kb/s	1993	2001	History
Cable modems	1 Mb/s	1998	2006	History
FTTx approaches	10 Mb/s	2004	2012	Forecast
Next gen fiber technology	100 Mb/s	2010	2018	Forecast
Big broadband technology	1 Gb/s	2016	2024	Forecast

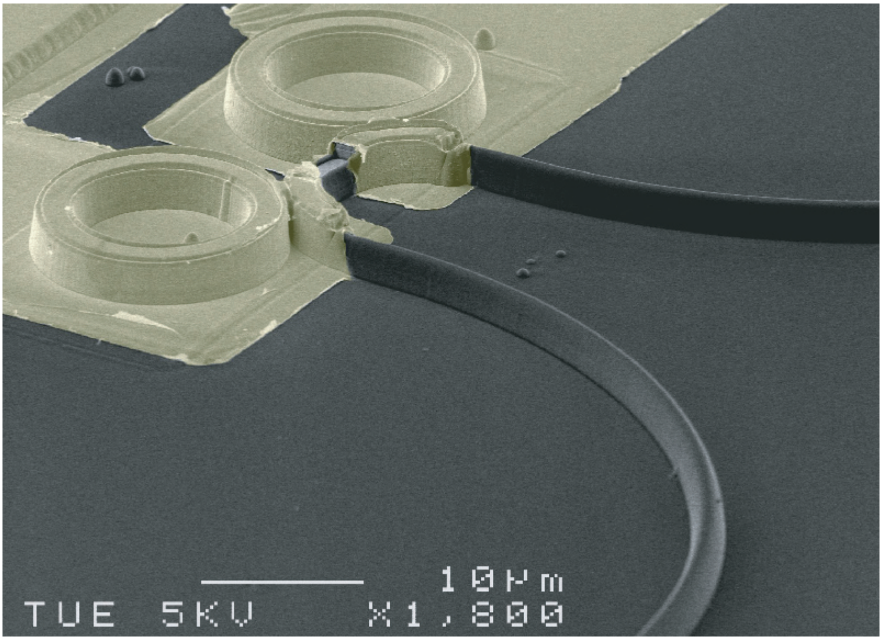
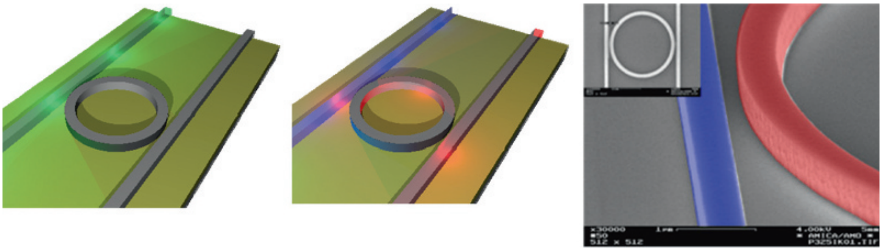


Fig. 2.1 Electron microscope picture of an optical flip-flop based on ring resonators with <18 ps switching time. The device has been fabricated at TU/e[10] and occupies approximately 60 × 40 μm^2

even higher switching speed up to 640 Gbit/s. Dekker and al. from the UT used a different approach and were able to achieve sub-ps switching in a compact silicon waveguiding structure (see Fig. 2.2).[11]

Will there be an upper limit to this development? Already more than a decade ago Harmen R. van As mentioned during an international conference that there will be

[11] R. Dekker, A. Driessen, T. Wahlbrink, C. Moormann, J. Niehusmann and M. Först, "Ultrafast Kerr-induced All-Optical Wavelength Conversion in Silicon Waveguides Using 1.55 μm femtosecond Pulses", Opt. Express, 14, 8336–8346 (2006).



Pump pulse: off Pump pulse: on Electron microscope picture of device

Fig. 2.2 Optical switch based on ring resonators with <1 ps switching time.[11] The device has been designed and characterized by UT in cooperation with the RWTH Aachen and occupies approximately $8{,}000 \times 15\ \mu m^2$

no objective limit in communication with respect to duration and speed.[12] In the not so distant future—he states—technology will provide virtually unlimited bandwidth for everybody, anytime, and anywhere. The only limit will be the subject, the human being, who has not more than twenty-four hours a day available for communication.

How long does it take for new technologies to achieve widespread use and impact society? And how does this process proceed? In many cases roughly five stages can be distinguished. There is first the discovery of a scientific phenomenon, based mostly on years of intensive fundamental research. Many applications of the technology are immediately foreseen, but it takes time to demonstrate the potential in a device or apparatus that can be shown to the non-specialist who eventually will be able to bring it to market. Often the engineers and scientists directly involved believe in their approach and start their own spin-off company to work on development and perhaps eventually on small-scale, commercial production. When shifting to large-scale production the impact of the new technology on society becomes visible with all the beneficial and sometimes less attractive, unintended consequences. In the previous phases, certain societal aspects have already been explored, but only after large scale application the juridical and ethical issues will be analyzed and solved. There is no law established for the different stages and their duration. Yet based on empirical observation one could set-up the following normal schedule:

Year X: discovery of scientific phenomenon
Year X + 10: demonstration of application in laboratory
Year X + 20: start of commercial production
Year X + 30: impact on society becomes visible
Year X + 40: ethical and juridical issues studied and (often) solved.

When applying this schedule to ultrafast communication one may expect that within the next two decades a number of far-reaching developments are made. First there is a seemingly unlimited "tele-presence" with audio and video that

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[12] H. R. van As, Vienna University of Technology, private communication.

includes—in a later stage—perhaps even touch and smell. The application fields include entertainment, education, healthcare, the nursing and caring industry, as well as things related to safety and vigilance.

But not only what we call "the real world" will be connected. Virtual worlds are already part of our real worlds—created by human-computer interaction, Second Life is one example.[13] The access to these increasingly sophisticated worlds will become easier with fewer technological limits. What is called "intelligence" will be everywhere around us, at home, at the office, on the road. The technological basis responsible for this is the presence of personal networks around us which are built of all kinds of mobile devices and is connected by broadband to powerful servers and databases.

In an optimistic but nevertheless realistic view, truth and knowledge in all fields of human activity can be regarded as positive. This is valid even if one takes the considerable risk of potential misuse into account. This fundamental openness to progress applies also to technology of ultrafast communication. One should, however, also consider the inherent threats of the new technology. One finds, for example, possibility of new forms of intimidation and criminal behavior such as identity theft and voyeurism. The efficient control and manipulation of individuals and groups can become easier. Considering the single person in front of the new possibilities, one discovers new forms of addiction and, in consequence, new forms of exploitation of persons.

2.3 Measures to Be Taken

In order to emphasize the positive aspects of ultrafast communication and to avoid both the misuse and less desirable consequences, three steps are proposed:

1. *Create conditions for a dialogue between experts in ethics and technology.*

This apparently redundant point is nevertheless not so obvious. The reason is that beginning in secondary education our society creates a sharp separation between the studies in humanities ("alpha-studies" in the Dutch nomenclature) and science or technology ("beta-studies"). This separation commences in the first years of secondary school education where talented pupils are faced with courses exclusively in a single of the two mentioned subject areas. Why should a future engineer or scientist spend substantial time in studying history and classic languages instead of concentrating exclusively on physics, mathematics, and modern languages? And vice-versa? As a consequence of this unnecessary specialization, there is not only a fundamental ignorance of the other subject area, but sometimes even a certain mutual disdain. Apparently, in our enlightened age the old ideal of the *homo universalis* is not valid any more.

[13] http://www.secondlife.com.

There are several other issues that would make the dialog embarrassing. The expert in technology is mostly a specialist in a certain field of technology, often working in industry or commercial environment. His colleague in ethics, however, could be classified as a generalist, and is connected mostly to governmental or semi-governmental institutions (at least in Europe). Their language is different, as the jargon in the one field is unknown to the other.

2. *Work out scenarios for the introduction of new techniques in society.*

As explained above, the evolution of technology is often accurately predicted years or even decades in advance. Detailed roadmaps are established and business plans are made. These roadmaps are extremely important, as is illustrated by Moore's law predicting the increase of density of the electronic building-block—the transistor—on integrated circuitries.[14] This law has been valid for approximately four decades, starting from a few to currently one billion transistors per chip. This has only been possible through a common effort of an industry including millions of man-years of research and development (R&D) activities worldwide. There are a large number of roadmaps describing mostly a confined range of technological activities. All these start with past and today's state-of-the-art knowledge and then extrapolate with increasing uncertainty into the future. The uncertainty arises from nature, as technological breakthroughs are not directly related to quantitative effort in man-year and capital. But even more important to the timeline is the decision to put more resources into the development and the acceptance of the products made possible by new technologies. Here the unpredictable behavior of decision makers and end-users—free human beings—determines the success of technological innovation. In other words, what started as a technological issue is confronted with the world of humanities and the social sciences, which besides economics includes a broad spectrum of other disciplines. The response of the decision makers in any stage of the roadmap (and eventually the end-users) will determine the effort spent in implementing the roadmap.

The impact on society of a new technology depends on the acceptance of the technology by human beings. Therefore a joint effort has to be made by experts in the humanities as well as technology. In this way, scenarios can be made that alongside technical details include the contribution of disciplines dealing directly with man and his behavior. In order to illustrate this point one could recall the above-mentioned comment from the mid-nineteen-nineties, that the only limit in communication will be the limited hours a day the human being is able to communicate. Otherwise, there would come unlimited bandwidth anytime and anywhere. The uncertainty at the time of the prediction was not whether it would happen but only when. Similar far-reaching statements can be made today in other fields. It is important that the knowledge already now available in technology-related forums would be evaluated with regard to economical, juridical, pedagogical, psychological, sociological, medical, ethical, and other aspects. In this context ethics plays a

[14] see http://www.intel.com/technology/mooreslaw/index.htm

guiding role, as it provides the last word about the good use of a technology. For example, non-profitable technical developments—like walking on the moon—can be carried out because of a higher cause. An unethical application, where one could include the use of certain weapons of mass destruction, however, should be hindered even if it is connected with large economic profits.

A personal experience with scientists and engineers working on technology related scenarios could be mentioned. If one asks the people that are directly involved in technology the same question one does not always get the same answer. The reason for this is the different personal background and capacity to reflect on one's own scientific and technological effort. For a reliable view it is advantageous to be used to work on a meta-scientific level and—probably more important—to have the memory of several decades of active work in the field.

3. *Anticipate opportunities and threats.*

As mentioned before, the scenarios are increasingly uncertain when extrapolated further into time. In the major developments, the uncertainty is mostly related to the time of introduction and large-scale implementation. Concerning the roadmaps of specific issues, however, certain developments may be cut out completely. This demonstrates the high risk of investment in a particular technology. For example, the results obtained in our own TUC project will perhaps never directly be used in any future commercial production or product. Thus, when considering ethical aspects one probably should concentrate on the major developments (where the risk is reduced), as one can concentrate on certain device or system concepts which are largely independent of the specific technological implementation.

Once a scenario is worked out, it is possible to identify action points to arrive at a good use of the new technology. Currently, for example, we see in the Netherlands a nearly 100% penetration of broadband access and multimedia in families with school-age children. This situation could be foreseen at least a decade ago, see, for example the comment of Harmen van As made in Section 2.2. But only recently has society reacted to the new situation. Now children are consciously educated for a useful and enjoyable application of the new media, and there is consequently concern how to avoid any form of addiction. There is a demand for measures against undesired contacts (strangers) and undesired content (adult content). The juridical system, however, is not prepared for the new situation. In addition, research is needed on the long term consequences of intense use of multimedia with regard to health (RSI, obesity, changes in thought patterns), social behavior, creativity, and the ability to concentrate on intellectual work.

2.4 Conclusions

The main conclusion of the foregoing is that there is urgent need of an ethical component in technology research. Furthermore, it is not easy to organize the effective cooperation between experts in technology and ethics. In the case of environmental issues, it is already common practice that for a new project with impact on the environment an Environmental Effect Report is produced in which the possible impact of the project is documented. In analogy to this one could suggest a Technology Effect Report (TER) every time a larger technological project is started, especially with public funding. This report should be a public document where a certain technological development and its possible alternatives are studied. On this basis then the expected consequences for man and society can be described in as systematic and objective as possible way. Once a TER has been worked out, the ethical evaluation proceeds to provide input for the decisions needed at critical points in the development and introduction of the new technology. These decisions, it should once more be emphasized, are made to enforce the positive aspects inherent in new technologies and to avoid the negative aspects as well as possible misuse.

The most important effect of the work on a TER could be that the two worlds of the scientist/engineer and the expert in humanities/social science would interact with each other. Often the first are not trained to reflect on the human and social aspects of their technology, whereas the second group does not realize the potential of currently-devised and often already demonstrated technological findings. By working together, the scenarios could be broadened to include all actors in the development of a new technology, reducing in this way the risk of poor decisions and improving the ethical character of technological progress.

The proposed activities are ambitious and much time from experts in technology and ethics is needed. Here the saying, “time is money”, is valid. On the long view, however, one may expect that investments in well-used technology, i.e., ethical technology will be even more economically profitable than the quick and often expedient rush to market with technology of unknown character and social effect.

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