Chip Design in the Baltics: Fact or Fiction?

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40 years passed this spring since Gordon Moore made his famous observation – that the complexity of electronic chips tends to double every 18 months. Four decades later, Moore's Law, as it is known, is still in place. There can probably be no more suitable moment than this anniversary for taking a look back at the history of the electronic chip and then trying to envision the future. How long could these rapid developments continue? What are the implications for the public? Last but not least, what on Earth do Estonia and the Baltic States have to do with the design of state-of-the-art chips? Is this geographic region really a backwater in terms of technology development? Or is it perhaps that top-level knowledge and know-how are simply still largely undiscovered by the microelectronics community?

INTRODUCTION

For more than 40 years now, the evolution of semiconductors has been based on Moore's Law, which says that their most important characteristics double once every 18 months. The most significant implication for society is that the function cost decreases by 25-30% each year, and that has significantly improved the quality of life in terms of the proliferation of computers, as well as telecommunications and consumer electronics. It is, however, an immense challenge for the semiconductor industry to keep up with Moore's Law and the rate of decline in the function cost, which has traditionally allowed for 15% annual growth in the market for integrated circuits [1].

In this paper, I will address primary challenges to Moore's Law and what should be done to maintain progress in the microelectronics sector. The main goal of this paper, however, is to offer an insight into the status quo in chip design and research in Estonia, doing so against the background of global issues. I shall describe successes that we have had in the research field. I will also try to analyse why we haven't attracted major investments from microelectronics companies, despite Estonia's favourable business climate and excellent infrastructure for research and information technologies. Should we abandon the dream of becoming players in the field of high-tech developments, or should we perhaps do things which will lead the IT community to consider opportunities which they might have in Estonia?

WHY DO WE NEED NEW DESIGN METHODS?

We have already looked at the main benefits which Moore's Law has brought to society, noting that it will be very hard to maintain this pace in the future. What are the greatest threats against the continuation of the semiconductor industry's phenomenal growth? First of all, semiconductor technologies, as we understand them today, are rapidly approaching their technological limits. The size of the technologies today is already very close to that of a single atom. It will take no more than two or three decades to achieve that milestone, and then an entirely new kind of technology will have to be adopted. No one has a clear visions of what the new paradigm might be.

Second the cost of designing chips has increased rapidly over the last few decades. According to Intel, a leading-edge chip required 100 designer months and contained 10,000 transistors in 1981 – that means 100 transistors per month. A state-of-the-art chip in 2002 required 30,000 designer months, and it contains 150 million transistors, or 5,000 transistors per month. The capacity of chip development, in other words, has increased 50 times over, and the technology has improved by as much as 15,000 times (Figure 1). As a result of this, design costs increased from $1 million to $300 million during the aforementioned span of time. The cost issue, obviously, will be acceptable only if more efficient design procedures are developed in the future so as to increase the productivity of designers [2].

In addition to the growing cost of chip development, there is also a tendency for testing and verification to play an increasing role in overall design costs. At the first IEEE/ACM/IFIP Conference on Hardware/Software Co-Design & System Synthesis in 2003, the industry stressed the fact that the ratio of testing and verification had reached a level of 60-80% of chip development expenses. It is crucial, therefore, for the electronic industry's competitiveness to focus on new design paradigms, particularly insofar as testing and verification are concerned. This would help to improve the productivity of the designer, thus minimising the time-to-market indicator.

As we can see from the aforementioned facts, it is important to focus on the development of more powerful chip design and testing methods. I will address the things that are being done in Estonia, and I believe that the situation in our Baltic neighbours is not much different. This is a success story, one which involves the emergence of a world-class research group and an environment for the design and testing of microelectronics in Estonia. There has, on the other hand, also been much less success in establishing major industrial links and interest. In this paper, I will seek to answer the question of what might have gone wrong and what might be our opportunities in the future.

BUILDING THE CHIP DESIGN INFRASTRUCTURE

There was an electronics industry in the Baltic countries, as was the case elsewhere in the ex-Socialist world. Estonia even had chip production facilities. As was the case elsewhere in the region, microelectronics technology was very much behind the Western level, and the industry finally collapsed along with the transition to the market economy. In 1991, when Estonia regained its independence, our role at the university was to adapt to an entirely new situation. There was a shortage of workstations, and CAD software that is necessary for chip design was extremely expensive. University salaries declined to the point where professors had no financing for researchers. On top of all of that, the research topics, language and style to which we were accustomed was completely obsolete from the Western point of view. It seemed that we had no chance to develop advanced microelectronics research in the near future.

Fortunately, there were people who chose to fight against the situation. One such person was Professor Raimund Ubar from the Tallinn University of Technology. In 1993, he began European Tempus projects with partners such as the Darmstadt TU in Germany and the TIMA laboratory in Grenoble, France. With the aid of these projects and the support of Mart Laar's government, a microelectronics design and testing laboratory was established in Tallinn. New international co-operation and Professor Ubar's personal charisma attracted many young researchers, myself included, to work on chip design and test methods.

The Tallinn University of Technology (TUT) became a member of the Europractice organisation (initially known as Eurochip). This fact should not be underestimated, because it made it possible for us to purchase professional CAD software for research purposes at only 5% of its commercial value. By the end of 1995, Professor Ubar estimated the commercial value of licenses at the centre to be roughly USD 4 million. The European project, along with donations from companies such as Ericsson (and, later, MicroLink), allowed us to equip our laboratories with Sun workstations and servers that are needed to run the microelectronics CAD. Visitors from various leading research centres in Europe were absolutely astonished to discover a research environment which exceeded the level of their own facilities. In just three years' time, this achievement was nothing short of amazing.

In parallel to progress with research facilities at the university, Estonia's overall IT infrastructure began to improve rapidly. Estonia, nicknamed "E-stonia" in the international press, is clearly one of the leading countries in the world at this time in terms of adopting the Internet and mobile communications. Estonia also has a really healthy business climate. The country has repeatedly been ranked in the top 10 in the world when it comes to economic freedoms.

Access to such a professional infrastructure and conditions, along with a strong research culture inherited from the Soviet era – these quickly led to successes in the scientific field. A number of innovative approaches were developed at TUT. These included a novel, hierarchical test pattern generation, hybrid, built-in self-test architectures, defect-oriented testing, and behavioural synthesis methods. Researchers at the department became members of the programme committees of leading scientific conferences. In 1998, Professor Raimund Ubar was awarded the I Prize in Technical Sciences. Many other prizes have been won by the research group since that time. In 2002, the Department of Computer Engineering at TUT received the highest ranking among all Estonian IT research groups in an evaluation that was carried out by an international jury. The department is involved both in the Competence Centre (academic research) and the Technology Development Centre (applied research) – these are national programmes. The most important reward in terms of acknowledgement for the research team was probably the decision to organise the IEEE European Test Symposium in Tallinn in 2005, with Raimund Ubar as general co-chair.

Recently the research group has established contacts with certain companies. In 2001, TUT signed a contract with a successful Estonian business, Artec Design, to regulate the co-operation activities. In 2003, TUT organised four educational workshops and courses for local SMEs in the field electronics, working together with companies such as JTAG, Xilinx, National Semiconductor and National Instruments for that purpose. Last year the laboratory began work on a new ELIKO Technology Development Centre project. ELIKO is the first centre to be financed in the national Development Centre programme, and the aim is to promote the transfer of knowledge between universities and industry. The aforementioned achievements in terms of co-operation with industry, however, cannot yet be seen as a huge breakthrough. The developments have certainly been insufficient for a centre which has such research facilities and for a university which trains 2,500 IT students at a time.

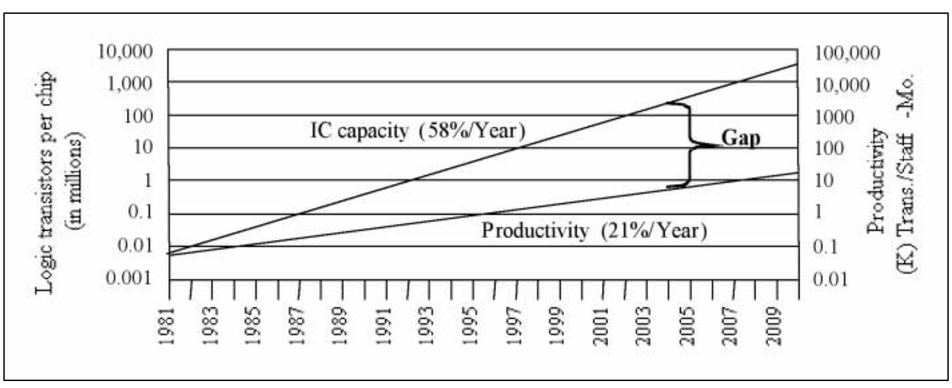

Figure 1. The chip design productivity gap (Source: [2]).

WHY DOES HIGH-TECH INDUSTRY AVOID THE BALTICS?

I have already mentioned the fact that Estonia has been very advanced in terms of adopting the Internet and mobile communications. On the other hand, Estonians are still just users, not designers of the technologies. No research and development centres, no design houses, no major outsourcing are a part of the work of any major players in the microelectronics market. A company in Tallinn called Elcoteq provides jobs mostly for low-qualification workers – assembly for mass production, for instance. There is only a limited amount of engineering going on there. Most local SMEs are very small and perform minor subcontracting tasks. At the same time, we also have large companies such as Nokia and Ericsson in the nearby geographic and cultural neighbourhood. At a recent IT forum, a professor from TUT asked a Nokia research representative why the company had not established any ties with the university. The Nokia rep talked about hard times in the IT sector. That may be a part of the answer, but it certainly does not explain everything.

Rumour has it that there are microelectronics giants in the Nordic area which are complaining that they could establish research centres here if there were a critical mass of educated microelectronics engineers. The point is, as noted, that TUT has 2,500 IT students who have access to a very advanced environment for design of electronics. Last but not least, the university has internationally distinguished research personnel. Particularly strong areas of activity included digital systems synthesis and testing, cryptography, analogue design, and biomedical applications. Naturally, we at the university must analyse what we are doing wrong, but it is very hard to tailor curricula to the industry's needs when there hasn't been the slightest indication of interest on their part.

Another point of misunderstanding when it comes to our colleagues in the West is that they expect that educated IT engineers will try to leave their home country at any cost. Global research institutes hire an endless flow of doctorate students from Romania and Russia. My experience tells me that IT engineers in the Baltic region, whether from Estonia, Latvia, Lithuania or Russia, tend to be very reluctant when it comes to moving to another country for a better job – even more so than is the case among counterparts in the West.

Average salaries in the Baltic countries are higher than in Romania, China or India, but an educated engineer in those countries costs more or less the same. The infrastructure and business climate in the Baltic States are considerably better. The only area in which these tiny countries cannot compete is the size of the labour force. We have seen, however, that only industries which require large numbers of unqualified personnel are entering the Estonian market. That is another paradox, and it is a complete mystery to me.

SOME IDEAS FOR THE FUTURE

I would like to conclude this paper with this thought: Building up excellence is not enough in and of itself. We must pay much more attention to promoting ourselves in order to break down the closed loop that is described above. We must explicitly point out our strong sides in high-tech development so that we might attract IT companies to the Baltic States. I suspect that most companies have no real idea of what is available here.

The average Estonian holds the illusion that the entire world is well aware of how progressive this country is. The truth is often quite the opposite – local high-tech companies and research centres have a hard time in trying to win the trust of their foreign partners. There have been some successes, but generally speaking there is still no knowledge about this geographic area and its cultural background – many people only know that we used to be a part of "Russia."

The government needs a clear strategy on how to make Estonia attractive to large microelectronics companies which are looking for qualified personnel and are planning to establish international design centres in our country. There should probably be greater effort in promoting our strengths at international fairs. Estonia needs stands at such events, it must bring in people who can provide a good overview of our areas of technology.

The amount of money which the government distributes via the Enterprise Estonia programme in promoting co-operation between research centres and the IT industry is, as such, adequate, but projects are very inefficient because an unacceptably high level of bureaucracy prevails. Too much attention is devoted to bookkeeping, planning and multiple audits, and there is virtually no focus at all on technological and scientific content. It would really be interesting to know how much of the money that our government allocates for R&D ends up in the pockets of auditing and consulting firms.

To end on a more optimistic note, I must say that there is still entrepreneurship in Estonia. I am pleased to announce that a new test and verification spin-off, Testonica, has recently been established by a group of researchers at TUT. The future seems good for the company, as there has been much interest from the microelectronics industry A couple of serious contract proposals from major countries are in sight.

A lot has to be done to create more highly qualified jobs in Estonia. I am not satisfied with that which has been done so far. I feel that much potential has not been implemented, and I am not sure at all what the feelings of our policymakers are in this regard. ❏

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