Improving DSP Design Expertise by Stepwise Educational Intensification

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ABSTRACT

In this paper different options for gradually building up DSP expertise will be discussed. First the importance of DSP design education in universities and polytechnic schools will be explained. Thereafter the paper will focus on the role that an independent research institute can play in the education towards industry in DSP design. It will be shown how DSP system design and implementation expertise is intensified by following different steps in the learning process. This will be demonstrated by means of several experiments that have taken place in the scope of the "DSP Valley" initiative and the "Large Installations Plan" of the "Human Capital & Mobility" Programme, which is a programme set up by the European Community.

1. DSP EDUCATION IN UNIVERSITIES AND POLYTECHNIC HIGH SCHOOLS

1.1. The fundamentals

A first role of the DSP educational process has to be played by Universities and Polytechnic High Schools. Their role in the educational process is to make students acquainted with new technologies. As DSP is a booming technology, it is important to give it an important role in the learning process. It will give student the fundamentals of DSP algorithm development, the implementation of DSP systems on commodity processors, the role DSP is playing in different application fields as e.g. telecommunications, consumer electronics, multimedia and others.
This important role of academic institutions has a considerable longer term impact. Students having obtained knowledge in this field, will use this knowledge once they move to industry in order to work on product designs. Although hard to measure the real impact, no one can deny the importance of making the expertise available at academic institutions to industry. Whereas in the past most of the university work was done on a local base in cooperation with local industry, it has been extended on a European scale, which brings us to the important role that EuroChip plays in this context.

1.2. The role of EuroChip

EuroChip is an ESPRIT VLSI Design Action aiming to increase the quality and number of engineers trained in VLSI design. The Action was launched by the European Commission, in the scope of the ESPRIT Basic Research Programme.
Any academic institution from EC or EFTA countries may join EuroChip and obtains in that way access to a wide range of services. These services include purchase and support of CAD software (both from commercial vendors as well as from research institutes and universities), access to chip fabrication and discounts on test equipment.
The EuroChip Service Organisation consists of a consortium of six partners which act as technical support centres for different regions :

- CMP, Grenoble, France : France, Belgium
- CNM, Barcelona, Spain : Spain
- DTH, Lyngby, Denmark : Denmark, Ireland, Greece, Finland, Norway, Sweden
- GMD, Sankt Augustin, Germany : Germany, Austria, Switzerland
- IMEC, Leuven, Belgium : Belgium, The Netherlands, Italy, Portugal
- RAL, Didcot, UK: United Kingdom.

On a yearly base, several workshops and training courses in the CAD tools made available, are being organised. One of the courses is being oriented to high level system design and is focusing on the design of telecom and DSP systems. Both IMEC and the University of Aachen are responsible for this part of the course. In total more than 1200 ASIC designs have been prototyped and more than 300 academic institutions are member of EuroChip.
Although EuroChip has originally been focusing on delivering services to academic institutions, it has broadened its scope recently in order to involve SME's (Small and Medium sized Enterprises) in the programme. In total more than 20 companies

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have already chosen EuroChip for prototype fabrication. This brings us to a next topic where more emphasis is put on the industrial educational aspects.

2. BUILDING UP INDUSTRIAL DSP EXPERTISE

2.1. Education - Design Concurrency

In the traditional approach the first step was to train people in a certain methodology or in the usage of new CAD-tools. Thereafter, they became involved in design projects, making use of this methods and tools. Nowadays however, the educational aspects on new design methods and using them for designs are intertwined. A considerable part of the learning curve in new DSP design methods is based on learning how to use a not-yet completed method or tool for advanced product designs. As such education in new methods and doing designs have to be done in a concurrent way. The same is true for designing and developing new tools, as stated in next paragraph.

2.2. Design - Tool Development Concurrency

In the past universities and research institutes have created new tools trying out examples of an academic scale. This has been the case for example in the development of place & route tools, in code generators for commodity DSP processors and so on. These tools have been taken over by CAD-companies for commercialisation purposes. Thereafter they were distributed on the open market and were used to do specific designs.

However, the new generation of tools in the DSP area, especially if they are oriented to global system design and implementation on heterogeneous types of architectures, contain a lot of knowledge about design methods and practices, embedded in the tools. These tools are not push-the-button tools any more. The purpose of the tools is to give experienced DSP system designers a significant breakthrough in efficiency by means of doing a lot of perspirational activities, such as providing the designer very rapidly with estimators for different cost functions, as e.g. memory usage, power dissipation, area occupancy, obtained throughput, load of different processing elements, and so on. As such it is for the designer much easier to make the right decisions at the very beginning of the system design and implementation stage, before he is already committed too far down in the design flow.

Therefore a permanent interaction is required in developing new tools and using these not-yet complete tools in a commercial design trajectory. By synergetically connecting both the DSP design technology providers and users, a dedicated solution can be obtained, serving specific requirements and needs of real users. In order to become acquainted with this new approach of concurrently designing/implementing systems and making the tools in order to make possible these designs, a gradual approach has to be followed, such that at the end a more and more intense knowledge of steering and using tool development is obtained.

3. GRADUAL PROGRAMMES

3.1. Trainings and Workshops

A first method to become acquainted with new DSP design methods and tools is trainings and workshops. A training is an ideal mean for a first introduction. It has to consist of an "ex-cathedra" course by specialists, a demonstration of the concepts presented and a hands-on session with a first guided experiment.

A training can be general or can be custom-made. A training can have different purposes :

- an introduction to a new technology for non-specialists ;
- an add-on to existing methods and tools at industrial partners' sites for specialists ;
- a feasibility study to investigate how useful the new technology can be and/or how the technology can be adapted to a specific industrial need ;
- an exploration to investigate further R&D cooperation projects ;
- a gradual introduction of new methods and tools by means of a prototype development.

Unfortunately in today's world, industry is often not realising the added value obtained by different training courses. A training course is in most of the cases a specific dedicated training to have short term results, but it is not considered as a strategic mean to steer further developments in the field and to gradually introduce new concepts in the "short-time-to-market" philosophy of industry.

On the other hand, workshops have gained a lot of popularity in introducing new concepts. A workshop has the advantage that all participants can actively participate in the discussions, but it has the drawback that it is often limited to R&D people, both from academia as well as from R&D divisions of large companies, that are focusing on very long term results. Often the link with real application oriented work is missing.

3.2. The Role of an Independent Research Institute

In this educational process it is important that an independent partner is playing an active role. This partner must also have enough critical mass and must have enough industrial relevance in order to perfectly match the offerings of stepwise education and the requirements from industry.

IMEC is an independent research institute in micro-electronics and related fields. One of the mission statements is to dedicate a considerable effort to the educational process, as well in an academic (universities, polytechnic schools) as in the industrial world. By making use of commercial DSP CAD-tools, by having developed own DSP development tools, which are being commercialised on the market by Mentor Graphics / EDC, and last but not least by doing real industrial designs, it is ideally placed to actively play a role in the educational process.
As an independent institute IMEC offers not only courses on own developments, but also on external developments and the use of external methods and tools. The example of EuroChip has already been mentioned before.

Another example is the DSP Valley initiative, being a network of two research partners (IMEC and Katholieke Universiteit Leuven) and four industrial partners (Philips ITCL, EDC/Mentor Graphics, EASICS, ISI), offering underlying technology for DSP system development. In total over 300 DSP experts are active in the Leuven region, working on complementary issues in the DSP system design and implementation trajectory. The partners jointly offer dedicated custom-made courses on the use of new methods and tools for DSP developments. Last year a course has been organised on "Improving Design Productivity for DSP Telecom & Multimedia implementations". This course will become a travelling seminar and will be organised on different places on a world-wide scale. In the near future a course on "Rapid Prototyping for DSP System Development" is envisioned.

Organising events to disseminate new methods and tools to the industrial community is a necessary, but not sufficient mean to gradually intensify the educational catch-up of expertise. Another important mean is making available the methods and tools to third parties on-site. This is what is done in the scope of the "Large Installations Plan" programme, an initiative of the European Commission.

3.3. The "Large Installations Plan"

This programme was launched in 1989 by the European Commission in order to support and facilitate the access to large scale scientific facilities in Europe.
The aims were threefold :

- provide easy access for EC-research workers to large scientific facilities ;
- to develop the use of large scientific and technical facilities ;
- to increase the scope for training offered to ED research workers.

IMEC has been qualified as a such a "Centre of Excellence" for its unique knowledge and software environment called CATHEDRAL. The CATHEDRAL environment is a DSP development environment for high-level synthesis and code generation of DSP-dominated systems. It starts from a pure behavioural or applicative description of a system and it automatically generates an IC-architecture at Register Transfer or Gate Level (in VHDL), satisfying performance and complexity requirements, and which could be used as an input to existing commercial CAD-tools from commercial CAD-vendors. Within IMEC this environment has been made available for :

- Experimentation : chip design for specific applications with immediate feedback from the software developers, research people and scientific specialists ;
- Complementary Research : adaptation or addition of special features to existing tools.

Because of the complex nature of today's design methods and tools, as explained before, and because the importance of being involved in the early stage of the design software development cycle, designers have to make use of the software before it comes available on the market.

In the scope of the Large Installations Plan, people can reside temporary at IMEC under favourable conditions in order to get deeply involved in the initial training and the follow-on experimentation or complementary research stage. Finally, the programme ends with a technology transfer action, in which some of the new methods, tools and/or designed building blocks are transferred and licensed to the partner who has participated in the programme.
As such the participants have obtained an in-depth knowledge in the new technology, such that they can further use it, further steer the research in the field and obtain a strategic competitive advantage for further product designs.

4. EXAMPLES

Several examples can be given showing the intensification process in new DSP design methods, tools and demonstrator design projects, starting from a first general training towards a technology transfer after the participation in the Large Installations Plan Programme.
A few of the many projects are given below :

- Thomson-CSF : Trade-off study of GSM implementation' on an ASIC versus a commodity DSP
- University of Madrid / Telefonica : Development of integrated speech recognition system on silicon, including the development of a test generation strategy
- INPG : Development of new scheduling techniques for DSP synthesis
- King's College London : Implementation of professional audio filters with CATHEDRAL
- Motorola : Use of CATHEDRAL methods and tools for telecom products and experimentation with new timing verification tools
- University College London and Royal Holloway : development of Scalable Microcontroller Library Element (SMILE) as an embedded microcontroller for DSP implementations

5. CONCLUSIONS

The use of DSP is increasing tremendously during the last years. Having an in-depth knowledge in the DSP domain is of key importance, because it is the driving force in the telecommunication and multimedia field. In the past, expertise in the DSP domain could be mastered very easily by attending a few high quality courses in this field. However today's DSP technology (algorithms, system design and implementation, simulation, prototyping, availability of commodity components, DSP ASIC development) has become so complex, that it is required to follow a strategic road by means of an "intensification process" in transferring and using DSP technology in order to stay on the leading edge.
This paper has given a few methods and ways in order to follow that road, starting from fundamental basic courses up to being actively residing at a large scale facility where method/tool developers and system designers/implementers are united in one place to bidirectionally nurture the DSP expertise transfer process.

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7. REFERENCES

[1] Progress Reports of the "Large Installations Plan", internal reports IMEC, 1989-1994.
[2] The Cathedral-2/3 Silicon Compiler for Real Time Signal Processing", IMEC training course.
[3] Survey of the Users of the Large Installations Plan, CEC, EUR 14461 EN, Sept. 1991.
[4] Evaluation of the Large Installations Plan 1989-1992, EUR 14409 EN, June 1992.
[5] EuroChip Newsletters, EuroChip, 1993-1994.
[6] Proceedings DSP Valley "Improving Design Productivity for DSP Telecom & Multimedia Implementations, Leuven, April 1994.
[7] Design Tools & Methodologies for DSP Systems - An Industry Report, Forward Concepts - Berkeley Design Technology Inc., Volume 1 & 2, 1993.

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