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A COLLABORATIVE WORK BETWEEN ACADEMIA AND INDUSTRY: THE CONCURRENT ENGINEERING LABORATORY

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Abstract. *The Concurrent Engineering Research & Development Lab (NuPES) is a University-related spin-off, which works closely with the Siemens subsidiary for telecom in Brazil. At the Federal Center for Education in Technology (CEFET-PR), ten kilometers apart from the Siemens plant, computational simulations using CAE (Computer Aided Engineering) tools are used to validate both electronic and mechanical designs. The analysis performed may contain digital, analog or mixed simulations, thermal analysis, and EMI (electromagnetic interference) analysis. In the mechanical world, structural, thermal and tooling verifications are possible. An interdisciplinary group of professors and engineering students participates on real projects, with true schedules, which challenges them to provide additional information regarding potential failure spots and possible alternatives to design engineers at Siemens, prior to any kind of prototyping. Professors can keep up with modern techniques and methods, work in a multidisciplinary environment and assure the propagation of new experiences through regular classroom activities and extra courses oriented to professionals.*

Key words: *concurrent engineering, simulation , computer–aided engineering.*

1. INTRODUCTION

Brazilian companies are joining efforts to adapt to the new reality of global competition. Reducing time-to-market, meeting consumer expectations and improving product quality have been crucial, no matter what kind of product will be designed. In the state of Parana, southern Brazil, companies face this very same problem. One of the alternatives to leverage competitiveness is to establish a “Concurrent Engineering” environment. Concurrent Engineering (CE) is “a systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support”, state Carter & Baker (1991). This means that companies should take several steps to achieve a real CE environment, from getting people to participate in early phases of product design, communicate and transfer expertise in specific fields through the adoption of expensive computer software to design, verify and share date across the company. CE is also

known by many other names such as simultaneous engineering, parallel engineering, team design, concurrent design transition to manufacturing and integrated product development, among others. It is known as an evolution of what used to be called collaborative engineering.

It is not always clear to engineering managers whether new computer technology will bring them to new standards of design excellence or better "time-to-money" figures. It has been known that heavy investment in computer resources as well as human resources may be a waste if not accompanied by an adequate policy to introduce concepts like "design-for-testing", "design-for-manufacturing" and "design reuse". Design engineers are often scheptical about new approaches that will interfere with their "creativity".

In the telecom industry, extensive use of EDA (Electronic Design Automation) and CAE (Computer Aided Engineering) tools that allow numerical simulations can be of great help to test designs early in the design cycle, even before any prototype is built, to detect virtual failures and reduce time-to-market considerably. There are many kinds of simulations: vibration analysis, structural behavior, injection mold-filling, 3D air flow simulations in cabinets, digital and analog circuitry simulations, high-frequency design simulations, thermal behavior of PCBs (Printed Circuit Boards) and so on. If there are any design problems, they can be pointed out in early phases, before errors have to be corrected and much time and engineering hours are wasted.

Siemens Telecom in Brazil has also been trying to incorporate better design practices into their product development process. Brazilian laws stimulate local companies in the computer/telecom business to invest part of their revenues in research and development, both inhouse as well as in research & educational centers. For this purpose, the Federal Center for Education in Technology of Parana (CEFET-PR) has been called to collaborate. In December 1994, the Concurrent Engineering Research and Development Lab (NuPES) was formed. Since then, this group of professors and students has worked closely with Siemens, to accomplish CE concepts and understand its implications (Borsato, 1997).

Several authors mention that CE has some "influencing agents" (Baker & Carter, 1991; Prasad, 1997; RosenBlatt & Watson, 1991). These are known as "the seven T's of CE": technology, tasks, teamwork, training, time, talents and tools. This paper presents how the CE Research & Development Lab is working together with Siemens to support all these issues.

2. THE NUPES TRIPOD

NuPES was created to accomplish three main objectives: to participate in real projects with Siemens Telecom, to provide specific training in CAE tools to students and engineers and to develop applied research in CE related areas.

The participation in real projects establishes a unique opportunity for teachers and students to learn about industry design practices and difficulties. On the other hand, design engineers at Siemens have access to a team of experts in specific areas of CAE, when needed. Computer simulations were not part of the product development process at Siemens before this program started.

As for training, every year dozens of engineering students and design engineers attend special classes to learn about CAE tools and how these should fit into a CE environment. The same teachers who participate in authentic projects are the ones who convey up-to-date technology in these classes. The association of practical experience and theoretical knowledge brings to the third objective of NuPES: investigation in techniques that will improve product development processes..

3. THE SEVEN "T'S" OF CONCURRENT ENGINEERING

3.1 Talents

Talents mean human resources. Many companies hire engineers that have reached excellence in science, but do not have the required skills for a job. That is why it is very important for students to be exposed to what engineers face on a daily basis.

Every year a new group of notable students is selected to participate in this program. They are supposed to stay in the team for two full years. This is to create an atmosphere in which elder students teach procedures and techniques to the younger ones. Every year, half of the group is replaced. These students are considered ready to become trainees at different companies.

During these two years, all kinds of possibilities to acquire knowledge are provided to the students: seminars, training, Internet access and so on. However, the most efficient method to learn about technology is to justify its need, through real design tasks, and offer assistance, through the direct assistance of teachers. At the NuPES R&D Lab, 41 students and teachers with several areas of expertise interact, plus design engineers who get together to discuss alternatives for better designs.

3.2 Tasks

Tasks are the next influencing agent of CE. The introduction of new products is done at Siemens. As soon as a new product is specified, a multidisciplinary team at NuPES is built, under the guidance of an experienced teacher. He or she will coordinate all analysis to aid design engineers find the best solutions to achieve high quality standards. The scope of the simulations is defined in common agreement with engineers at Siemens. The task coordinator holds design reviews periodically with the design teams, to report results and suggest possible alternatives in time, so that changes are made before any physical prototype is built.

A NuPES team may conduct other kinds of activities, such as software customization and verification. If there is a new tool being considered for purchase at Siemens, this should fit into the design phases and provide some kind of advantage to the designer. A team at NuPES verifies its interface with other computer programs and database compatibility, using known design cases. Moreover, any computer program may be customized to fit into Siemens' development processes and standards.

3.3 Training

Training is essential to establish a successful CE environment. It is imperative that all designers are proficient in the tools they use. Training provided by software vendors has been traditionally expensive and inadequate to the customers' needs. NuPES has offered training in several modalities, like formal training (classroom/lab activities), self-training (tutorials and manuals), consulting (bringing experts to the lab), and so on. When there is no formal training available, a NuPES representative may be sent abroad for specific classes. He or she will be asked to disseminate what he or she has learned to other teachers, students and designers.

3.4 Teamwork

Teamwork is one of the most important agents in a multiple-site design environment. If design changes are to be implemented, a common database should be shared across the design sites. Not all computer programs allow automatic design updates or version control. When this happens, it is crucial that communication among all parts works fine. Extensive use

of e-mail and teleconferencing is an alternative for the exchange of information. Our design teams have used e-mail successfully, after some rules were established. For example, any message that might be relevant to other designers should be sent to the whole design team. For this purpose, the task coordinator creates aliases for each project and defines responsibilities. Every member of the design team is then able to know why a certain delay is happening or even where there is a bottleneck.

Some other tools to manage projects have been considered by NuPES, like Mentor Graphics' WorkXpert™ family. NuPES is currently investigating whether they will suit Siemens' needs in this area.

3.5 Tools

Tools are frequently understood as means to implement CE. Of course, the more tools support CE concepts, the better, but the are only one of the influencing agents. Tools mean not only the computer software that supports design, but also any other item to build a network of services that permit re-usability, database consistency, information sharing and compatibility.

The NuPES program has invested nearly 75% of its funds in software/hardware purchases in the last three years. As figure 1 illustrates, two laboratories were built: the first is a research facility at CEFET-PR with 19 UNIX workstations and 11 PCs, directly connected to other 12 UNIX workstations at Siemens, where the projects' databases are kept, as well as the CAD (Computer Aided Design) library. Computer programs like Mentor Graphics™' EDA suite of tools, PTC's Pro/ENGINEER™ solid modeling system, Ansys™ FEA (Finite Element Analysis) package, C-Mold™ injection molding simulation software, Flomerics' Flotherm™ CFD (Computer Fluid Dynamics) package, and others are currently being used in the research laboratory. Besides computational resources, there's a rapid prototyping system that uses fusion deposition technology to build 3D parts in ABS resin.

A second lab (NuPES/RLE) was built for educational purposes, so that all classes may utilize the same software versions as those used for product development. It has been possible to sign off special agreements with software vendors to have their educational products running in this lab.

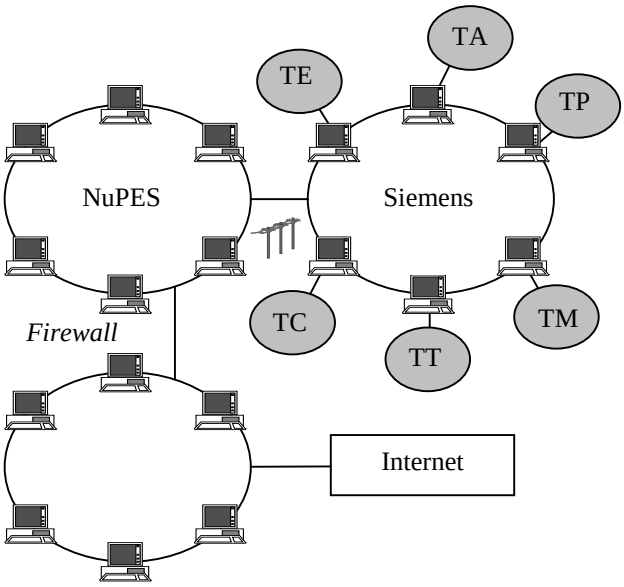

Figure 1 NuPES/Siemens cooperative network.

A firewall system has been installed to prevent hackers from having access to classified information. Still, the research facility may access the Internet to gather data that will be useful for simulations.

3.6 Time

Time is directly connected to the reality of the telecom business today. Most products have to meet tight schedules. Otherwise its sales forecast will never become true. Some other competitor might introduce a similar product before, lowering profit. Design managers are often faced with the news that they will have to reduce costs and time-to-market if they want to survive global competition. On the other hand, design engineers often say they have no time to design right the first time because they are too busy getting ready to re-design. Moreover, alternative design techniques are forgotten because they are not reliable, until engineers are forced to use them not to lag behind the competition.

The NuPES design teams work on the same schedule constraints as Siemens does. This has been one of the toughest challenges in this program, as teachers are not used to the pressure engineers are. Their hunger for perfect results need to be replaced by “whatever is possible to do” if a schedule is to be met. That is why not all possibilities are to be investigated in a round of simulation runs.

3.7 Technology

The need to manufacture better products and faster has led to massive investments in new areas of the human knowledge. Terms like rapid prototyping, DFT (design-for-testing), DFM (design-for-manufacturing) and virtual design are relatively new to engineers. NuPES is currently working with Siemens to incorporate new design practices, which will somehow reduce time-to-market.

Design engineers do not usually have the time to investigate new alternatives to their processes. Instead, teachers and students at NuPES can test tools that look interesting at first, but might not be appropriate when applied to the company's processes and practices. It is too expensive to buy tools and then find out that they are not as good as they looked when a salesman suggested their acquisition. Therefore, all new technologies are experimented on real designs to provide engineering managers enough insight (pros and cons) to be able to make a purchase decision. Some of the areas already investigated are rapid prototyping, FPGA synthesis and verification with VHDL, EMI (Electromagnetic Interference), among others.

4. BENEFITS TO CEFET-PR AND SIEMENS

It is notorious that both partners have benefited a lot from this engagement. From the school standpoint, this has been a unique opportunity to bring teachers to a higher level of expertise in new technologies. This has immediate effects in their performance in class, as they convey best practices and experiences to students. The access to industry standards is another positive aspect of this experience. There is no other way to gather this knowledge, other than working together with real designers. This happens continuously, as new projects take place. Moreover, teachers are motivated because they know that each one of them is currently working on state-of-the-art technology, and earns a salary complement.

Another benefit that could be mentioned here is the generation of a new standard in the education of engineering professionals. Parallel to engineering curricula, students have had access to the environment they will be exposed to in a few months. Meetings, conflicts, debate and the chance to make one's point to an experienced designer or teacher are unique.

Also, the first contact with foreign consultants is very important in this phase, as the need for proficiency in a foreign language becomes obvious. Each student has been given the opportunity to know several different areas of expertise before they have to make a decision when they are to join a company. The saying: "do what you like the best" is probably the first step for a successful career in engineering.

CEFET-PR has been able to establish two advanced laboratories: one for research and development purposes and another for courses. These might be regular classes as well as special courses for companies nearby. Furthermore, the relationship between industry and school has been tightening up since the school has means to find out what their students need to know to get a job.

As for Siemens, the benefits are far more evident. The areas in charge of hardware development have been able to incorporate new techniques into their design processes. Numerical simulations were not part of the design practices of these areas at Siemens before the Concurrent Engineering R&D Lab was established back in 1995, nor the value of the results. Actually, very few design engineers had had access to this technology, apart from demos provided by software vendors, which, of course, do not give much insight of what is involved once one tries to apply simulations on real projects and processes.

Another benefit Siemens has had with this program is the possibility to review and optimize their development processes. A written specification on how this cooperation in PCB design has been delivered, adding new features and consolidating practices that had been taken place for years.

Concurrent Engineering implies in the integration of several different areas and sharing of information. This program has put key areas in contact to reduce time delays and pass valuable information. It is true that there is a lot more to be done to establish a real CE environment at Siemens .The organization needs to be modified to adapt to a more "project-oriented" approach, as opposed to the traditional "function-oriented" approach currently used by many companies. This requires time and a profound culture shift. NuPES has held workshops in which experts talk about best practices and the theory behind CE concepts.

NuPES has been providing continuous training to designers at Siemens, as new tools are introduced. Software vendors may be contacted to provide training once in a while, mostly when there is no in-house expertise available. This represents thousands of dollars saved by the company, and an opportunity to stimulate training: a job that can be perfectly combined with the fulfillment of new designs. The portfolio of courses offered by NuPES to Siemens is updated every year, just as the contents are. In many cases the tutorials offered by software vendors do not match the specific needs of engineers and many training hours are wasted.

One of the most relevant benefits Siemens has obtained through this program is the possibility to test new tools. The staff at NuPES is capable of judging whether new tools are of any interest at Siemens, by testing them against previous designs. Experienced designers are then asked to verify this new functionality. This way designers do not have to invest their time in testing and purchases are based on more realistic data, rather than simplistic promises, demos and brochures.

Finally, NuPES has introduced trained new engineers that will easily adapt to Siemens´ needs, as they have already been involved in real tasks with experienced designers. Many students have continued their work as trainees at Siemens and will eventually get a job there or outsource their workforce in specific areas. This has been one of the main purposes of this school throughout the years and NuPES has achieved great success in delivering what is most required from an engineer: competence and creativity.

5. SUMMARY AND CONCLUSIONS

In this work, a new approach has been presented to minimize the current distance between industry and academic practices. Students are asked to participate in this effort, as they will benefit from this flow of information that takes place and utilize modern computational tools in real life situations. Students who graduate at CEFET-PR will have better conditions to compete for job opportunities as the industry recognizes the need for this expertise.

Professors can keep up with modern techniques and methods, work in a multidisciplinary environment and assure the propagation of new experiences through classroom activities and extraordinary courses oriented to professionals. The contact with state-of-the-art simulation tools brings up their curiosity for on-going development advances, of the tools they work with.

Companies can see universities as partners that provide service and new human resources. This partnership brings new development procedures to their environment, so their processes have to be reviewed constantly.

The Concurrent Engineering R&D Lab is an on-going experiment. It is a tentative to adapt industry and academia, to insert them in a more competitive global reality.

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