Remote access to expensive SDRAM test equipment: Qimonda opens the shop-floor to test course students

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Abstract— **Remote labs are increasingly used in a variety of blended-learning scenarios, with the objective of complementing the work done in real labs. In such cases, the workbenches present in the real labs comprise a set of instruments that may be used over the internet. The lab work to be done by the students may be carried out from any location within or outside the campus, enabling them to carry out their assignments from home or from any other place, at a time of their choice. However, remote experimentation is not necessarily related to students accessing academic labs. Small and medium-size companies may be interested in specialised equipment available in university research labs (e.g. an electron microscope). Alternatively, student skills in various areas may be improved if they are able to work with equipment available in factories or other industry installations. This paper describes a collaboration initiative between the Qimonda SDRAM factory at Vila do Conde, in the vicinity of Porto, and the Faculty of Engineering of the University of Porto (FEUP), whereby an expensive test station used by Qimonda SDRAM factories is remotely accessible to test course students in higher-education institutions.**

Index Terms— **Remote experimentation, memory testing, automatic test equipment.**

I. Introduction

Qimonda is strategically interested in contributing to improve education and training opportunities for higher-education students in engineering and other areas relevant for SDRAM production. Qimonda's manufacturing factory in Vila do Conde, located in the vicinity of Porto, being one of the company's most important production facilities worldwide, is a major employer of engineering graduates in various specialization areas. Test engineering is one of those areas, and plays a vital role in Qimonda's successful SDRAM manufacturing business. Since remote engineering tasks are a common practice within Qimonda, a decision was taken to allow university students to remotely access a T5365 Advantest® station, illustrated in figure 1.

The T5365 and many other SDRAM test stations are not only very expensive to acquire, but also very expensive to maintain, and as such are well out of reach to university budgets. For this reason, they are not available to students in general test courses. Even when such courses include memory testing topics, the contents presented to the students can barely go beyond the theoretical aspects. A visit to the Qimonda shop-floor may show the students what memory testing looks like in real life, but their practical knowledge in this area is at best very scarce. Lack of access to real training conditions is therefore a strong bottleneck in the education of test engineers, and contributed to trigger the company's interest in FEUP's Labs-on-the-web project, which provides remote access to laboratory workbenches. The resulting cooperation project between FEUP and Qimonda is the main subject of this paper.

Figure 1. Advantest® station for SDRAM testing [1]

A brief description of the test engineering activities at Qimonda is included in section 2, followed by a presentation of various remote engineering tasks that are intrinsic to the company's test engineering division. Section 4 presents the Labs-on-the-web project, and section 5 summarises how remote engineering and remote labs came together to provide better education and training opportunities to engineering students.

II. Test Engineering Activities at Qimonda

Each SDRAM produced at Qimonda undergoes extensive electrical test in order to assure the demanding quality requirements. Typically, the next generation of Automatic Test Equipment (ATE) is developed in parallel with the next generation of SDRAMs, because both are state-of-the-art [2]. In a "backend" factory, such as the one located in Vila do Conde, the investment in test equipment is higher than the investment in all the assembly equipment. Being capital-driven, Qimonda factories work continuously, 24h per day and 7 days per week, to optimize the equipment utilization.

As a consequence of the extremely high cost of the test equipment, test program optimization is an ongoing activity [3]. The upcoming investment needs are planned based on aggressive roadmaps of test time reduction steps defined for each new memory product before its design is even started. Test programs are customized for each new variant of memory product, e.g. technology, re-design or memory capacity, and evolve continuously alongside the evolution of the production process, so that the desired quality is obtained at minimum cost, that is, minimum test duration. While continuously struggling to minimize test time, the target quality must at all times be ensured. The test program must not screen more components than needed, nor let go to the customer components that will fail at their final application. Since SDRAMs are typically produced in very high volume any such unintended behavior of the test program would have big economical impact. This is why the same expensive production test equipment must also be used for R&D activities. New tests or optimization of existing tests must be developed and verified at the same type of testers that are used in volume production, to ensure that the test coverage is exactly the same that was initially developed.

Likewise the production sites, also the design, product and test R&D teams at Qimonda are spread all over the world. There are design centers (DCs) in Germany, in the USA and in China. Historically, product & test was located physically close to design teams, due to the high synergies between these areas. In 2003, a Center of Competence in High Performance Test was installed inside the facilities of the SDRAM backend factory in Vila do Conde and is delivering production test programs for at-speed test of the memories produced in all the Qimonda backends since 2004. More recently, other similar groups were created and are currently in an aggressive growing phase. While taking advantage of the proximity to their internal clients, the production site, the physical distance to the design and product experts is a challenge.

III. REMOTE ENGINEERING IS INTRINSIC TO QIMONDA SDRAM TEST DIVISION

Also at the DCs maximum utilization of the testers, all day long, is a must. For this reason, there are operators working at nights and weekends so that the long product characterization measurements can use the test equipment in these periods. When there are peaks in tester utilization needs or when tester types that are not available locally must be used, the engineers in one DC are able to access remotely to another development center, often taking advantage of the time zone difference between locations to use the testers at times when they are less utilized locally. For instance, an engineer in Vila do Conde may access an R&D tester in China. The operator in China will insert the right components at the tester, which will be controlled by the test engineer in Portugal.

At a “backend” such as the one in Vila do Conde, the production testers are located in the clean room. For efficiency, the engineering testers are placed close to the production testers. Being optimized for production activities, the clean room does not provide the best conditions for development work. At other development centers not located at a production site, the testers are kept in a lab apart from the office area due to the need for special facilities. In some cases, lab and office are not even within walking distance. Even when they are, it is often convenient that the engineers sit at their workplace in the office, and access the testers remotely. For example, the set of tools available in the Advantest® ATLworks framework shown in figure 2 are frequently used from the PCs at the office, provided the Devices Under Test (DUT) are previously placed at the test head.

An example of a typical activity performed by test development engineers at Qimonda is to debug a new test. After implementing the test, it must be checked that the golden components pass the test. If not, the cause must be understood in detail. Advantest® provides a set of tools to help in this task. As shown in the picture, the tool provides an oscilloscope-like display of the signals applied and read from the memory during the test. In the case of writing to the memory, the displayed signals are a representation of the output of the test program; in the case of reading from the memory, for each output bit it is indicated if the logical value at the programmed sampling instant is the expected one. This allows that the precise part of the test where the DUT (device under test) fails is spotted. Additionally, the actual memory output signals can be sampled and the analog shape displayed.

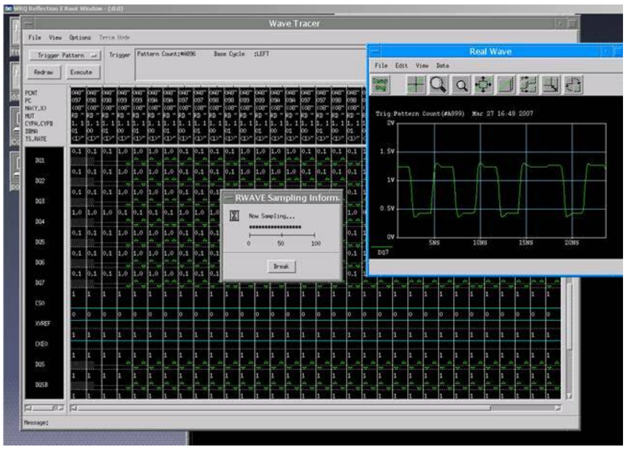

Figure 2. The ATLworks test environment

The outcome of a test is the combined result of the memory circuit itself, the test equipment and the implementation of the test program. The engineers that prepare the test programs must have a general understanding of the memory product, but their expertise is in the test program implementation and tester characteristics. Other colleagues, that must know the product more deeply, are responsible for specifying the contents of the production test. When the result of a new test is not as expected, it may not be easy to identify if it is the component that is not doing what it is expected or if it is the test that is not behaving as it should, especially in the early phases of a product, when the product is not yet fully characterized. At this point, it is common practice for test and product engineers to physically sit together at the tester and solve the problem collaboratively.

When a test engineer in Portugal needs the support of a product expert in Munich, USA or China, the solution is to share desktops via Windows® NetMeeting® or a similar tool. They will see the same tester outputs, debug the code together, share control of the tester tools and talk over the phone or a chat tool. Figure 3 exemplifies this kind of setup. A test engineer in Vila do Conde is using the tester “qcx04” in China. He shares his desktop with another colleague, who sees at her PC exactly the same X-Windows session and both are able to control the remote tester. Figure 4 shows a chat session between a test engineer located in Portugal and his US-based colleague. It is often more practical to use such tools than to talk over the phone or use e-mail.

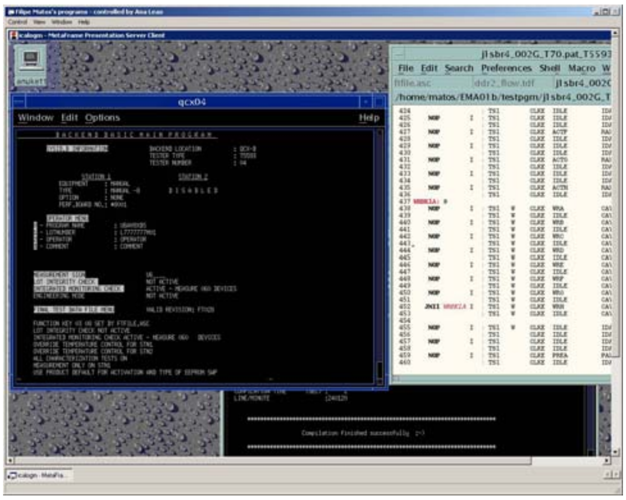

Figure 3. Remote control of an SDRAM tester located in China

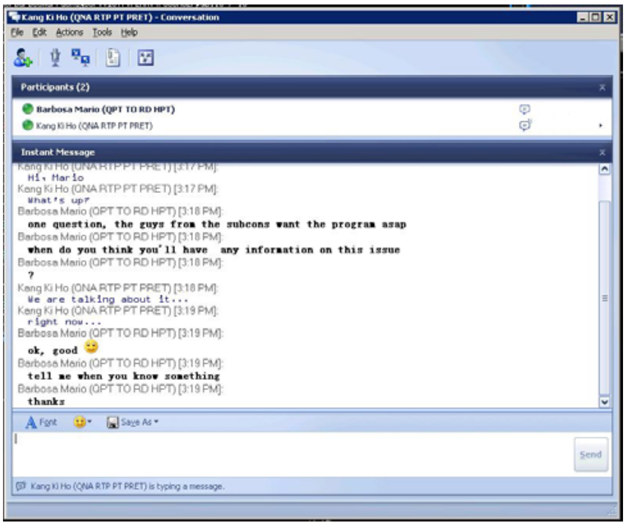

Figure 4. Collaborative working via text-based chat

IV. FEUP'S LABS-ON-THE-WEB PROJECT

Pedagogical innovation is a permanent concern at FEUP (Faculty of Engineering – University of Porto). Offering a wide range of high-quality e-learning contents, including web access to laboratory workbenches, is a key effort in this direction.

On-line workbenches – which are not meant to replace real lab sessions – offer several advantages [4,5]:

- They adapt to the students – an assignment that could not be completed in the lab, may continue from any other place, at a time of their convenience (the assignment may also be repeated, in case of doubts or missing data; or executed before going to the lab, when preparing the real lab session).
- Safety and security are improved, since there is no risk of catastrophic failures.
- For cost / benefit reasons – laboratory equipment continues to be available even when the lab is closed.
- Lab equipment may be used by high-schools, and other universities or companies, from home or abroad.

Live video channels embedded into user interface panels enable the students to visualize experiments as they take place in the remote lab, while videoconferencing allows synchronous communication among students collaborating in any given experiment [6,7].

The Labs-on-the-web project is funded by the Portuguese Ministry of Science, Technology and Higher Education, under the Science and Innovation Operational Program (POCI 2010). Its main objective is to assess the pedagogical effectiveness of online workbenches in engineering courses. Such workbenches are seen by the students as just another type of e-learning content, in addition to lecture notes, exercises, slides, self-assessment quizzes, etc.

The Labs-on-the-web consortium includes FEUP (Engineering) and FPCEUP (Psychology and Educational Sciences). The project work plan comprises three main topics: development of a range of remote workbenches in several engineering areas, a training program for teachers and other academic staff, and the development and application of pedagogic assessment tools.

The online labs made available to the students via the POCI 2010 Labs-on-the-web project include *virtual workbenches*, in the form of simulated environments, and *remote workbenches*, built from real equipment and devices. Figure 5 shows an example of a remote workbench that enables the students to control and observe the operation of an 80C51 8-bit microcontroller-based 220 V lamp dimmer.

Figure 5. Remote workbench offering a 220 V lamp dimmer experiment with integrated videoconferencing

The remote workbench illustrated in figure 5 integrates a Flash-based videoconferencing room to enable the students (and eventually their tutors as well) to exchange information while the experiment is being carried out. Notice also that the main interface panel provides live image feedback from the remote lab, showing not only a general view of the lab, but also the experiment hardware.

Virtual workbenches may be preferable for economic reasons, or whenever access to real devices brings no pedagogical benefit. Remote workbenches are recommended when the objective of the experiment consists of interacting with a physical device (e.g. to observe a given parameter), by safety / security reasons, or yet when the multidisciplinary nature of the experiment, or the proximity to real world conditions, make this alternative preferable. There are also cases where both types may co-exist, and other situations where it is possible to develop mixed-reality workbenches, where physical devices interact with simulation models in hybrid environments.

V. Qimonda + FEUP = Better Education and Training in Test Engineering

The standard remote engineering procedures at Qimonda and the objectives of Labs-on-the-web project provide a perfect combination to enable better education and training opportunities for test course students. With this objective in mind, the company is preparing a T5365 Advantest® station to be made available to FEUP students in the 2007/08 school year. The outcome of this initiative will help to extend this offer to students from other Portuguese universities and polytechnic institutions.

Qimonda's availability to host remote test sessions in the Vila do Conde shop floor will be offered to FEUP's students for the first time in the EEC0060 Electronic Test Systems course. The curricular contents of the EEC0060 course have been updated to reflect the requirements of SDRAM production facilities, in order to take full advantage of the sophisticated test equipment that is now available to the students.

Better education and training is actually only part of the benefits that are offered by this cooperation program. Test course students that have access to the real SDRAM test engineering world have knowledge and skills valued at Qimonda, and therefore possess competitive advantages when it comes to employment opportunities. On the other side, Qimonda has the possibility of hiring engineers who had the opportunity of using real tools and equipment during their education, which is an advantage for a wide range of positions. When the job does not directly require expertise in the test equipment, it is very unlikely that the engineer would ever have availability to develop this competence, but there are several functions related to test where this is beneficial. When the function more directly requires deep understanding of the test equipment, the training cost and duration will be reduced and the recently hired engineer will hopefully enrich the team with a wider theory and experimentation compared to the necessarily more focused on the job trainings at the industry. Besides providing know-how on the production test equipment, having the possibility of doing practical exercises at the tester will, as a side effect, increase know-how on SDRAMs operation or even internal design. Finally, the training material prepared within the scope of this co-operation project is also expected to be useful for internal training at Qimonda.

VI. Conclusion

On-line engineering is a daily practice in a company like Qimonda, which spans the globe and faces technical challenges that can only be overcome by multinational teams with a wide range of knowledge and skills. FEUP leads the POCI 2010 Labs-on-the-web project, where the engineering and educational sciences (FPCEUP) faculties evaluate the pedagogical effectiveness of remote and virtual labs [8,9]. Cooperation between the Labs-on-the-web project and Qimonda is only part of a broader plan that aims to bridge the gap between the company and various Portuguese academic institutions. Resources and expertise existing on both sides are frequently complementary, particularly in what concerns engineering education and training programs.

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