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VIRTUAL ACADEMY PLATFORM SUPPORTED BY A SEMANTIC KNOWLEDGE BASE

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Abstract: *This paper discusses about novel concept – Virtual Academy Platform of studying engineering and doing the micro controller based experiments for scientific purpose. The complete platform, consisting of virtual and real hardware together with knowledge base support is introduced. The results of developed concept are partly applied into practice in different universities, but the ongoing research is in progress to establish full concept near future.*
Key words: Virtualisation, µController, Semantic, CAN, Academy Platform

1. INTRODUCTION

Today´s Computer Science and Electrical engineering industry is characterized by rapidly occurring innovations and a continuous advancement of existing technologies. Therefore it is quite a challenge for the education institutions, to keep up with the high pace of technological innovation. Furthermore, European countries are facing the emerging competition from Asian countries. The education has to be made more attractive to young people and feasible to full-time employees in order to stabilize the European leadership in product development and to successfully compete with overseas-countries. Serious problems with the practical learning process occur in the higher education system itself. For education institutions the main problem is the availability of (often expensive) ICT based learning material for the classes, the lack of functional qualified teachers, and the lack of place in classes for capacious equipment. Another common problem is to exploit new Internet technology for practical education in these fields. The key point in engineering studies is to make practical exercises to get firm products used in industry.

2. CONCEPT OF VIRTUAL ACADEMY PLATFORM

With the Virtual Academy Platform (VAP) we are facing to combine new approaches in Internet technologies (e.g. Semantics reasoning, rich internet application) and MCU research (virtual µController solution) to build a modern state-of-the-art eLearning platform, which can be used over all educational areas.
The usage of information technology for teaching and learning not only supports these activities but also influences and forms their characteristics. In an increasing number of cases, learning processes and technical systems not only have a co-appearance but are highly interrelated. The result is a specific kind of socio-technical learning and teaching systems which have to be carefully understood. To achieve a successful adaptation between organisational processes and technical design a participatory development and design is needed. The participatory development of a socio-technical system can be supported by the methodology Socio-technical Walk-through (STWT) [1], invented and evaluated by the Department of Information and Technology Management (IMTM) at Ruhr University in Bochum, Germany. STWT is a facilitation method for knowledge

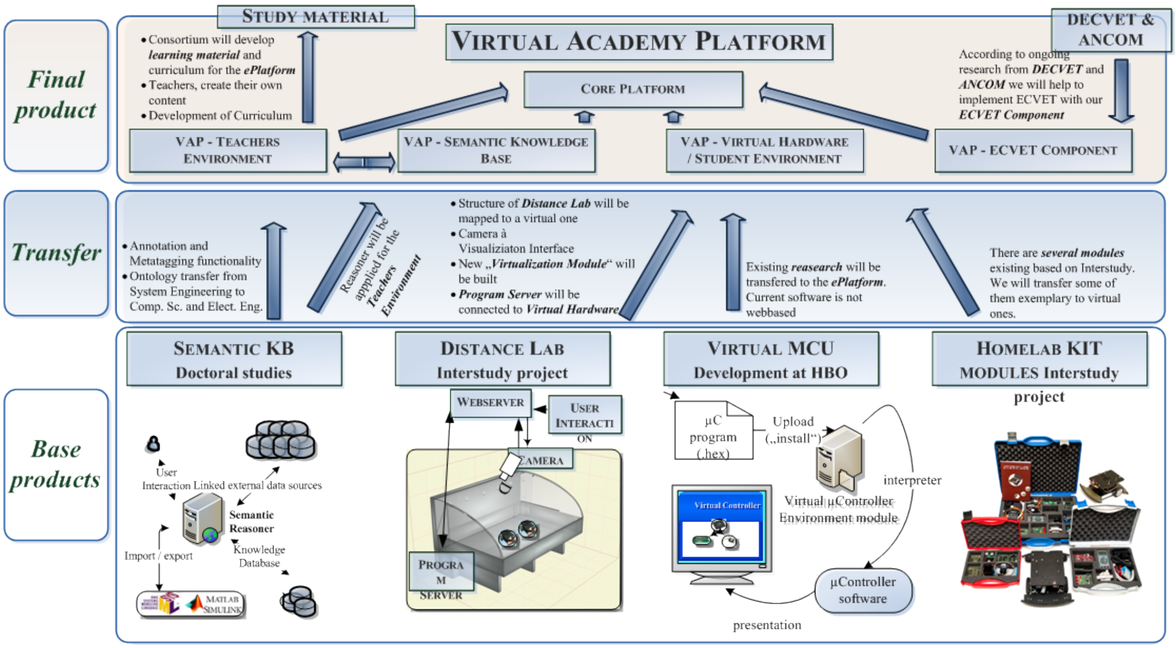

Fig. 1. Concept of Virtual Academy Platform

construction which aims at the improvement of socio-technical work and learning processes. STWT supports a series of workshops which are the basis of a participatory design process, including several participants and combining evaluation with design. It is used for the development of the VAP solution. The platform itself consists of four different base products, Semantic Knowledge Base, Distance Lab solution and HomeLab KIT modules from Leonardo da Vinci (LdV) project Interstudy and the Virtual MCU solution development based on LdV project MoRobE. Altogether these products are transferred, as presented in fig. 1 to a rich internet desktop environment based on Google Web Toolkit [2] (GWT) and ExtJS [3] as a technology base. VAP intends to be highly applicable to different fields of education, as new modules can be implemented by using the well-defined interfaces the *core platform* offers. VAP is covered by four assisting modules, Teachers Environment, Semantic Knowledge Base (with reasoning support), Virtual Hardware / Student Environment and the ECVET [4] component.

3. VIRTUAL MCU SOLUTION

As a µController is a special kind of hardware it is also possible to be simulated. According this approach there was already research done in Bochum, latest by a Diploma thesis dealing with this topic. The lack of existing solutions is based, that they are only focusing on registers and the outputs illustration. There is currently no common accepted visualization to this. Also a step-by-step execution of the code is not possible, as it is applicable with real hardware. These demands were the reasons to prototype a new simulated one, based on Avora [5], but with an extended Graphical User Interface. The general approach is illustrated in fig. 2. The Virtual MCU is currently in beta stadium and during further development we will evolve this prototype to a final stage to help to improve education in µController programming which is common in Mechatronics, Computer Science and Electrical Engineering education beginning in secondary school (technical classes), in vocational education and of course in the university world. Main goal is to create a virtual µController framework that allows a wide scale of experiments. The outcome will be a modular software framework that contains a virtual µController and virtual add-on hardware like Display, motor and RS232 interface.

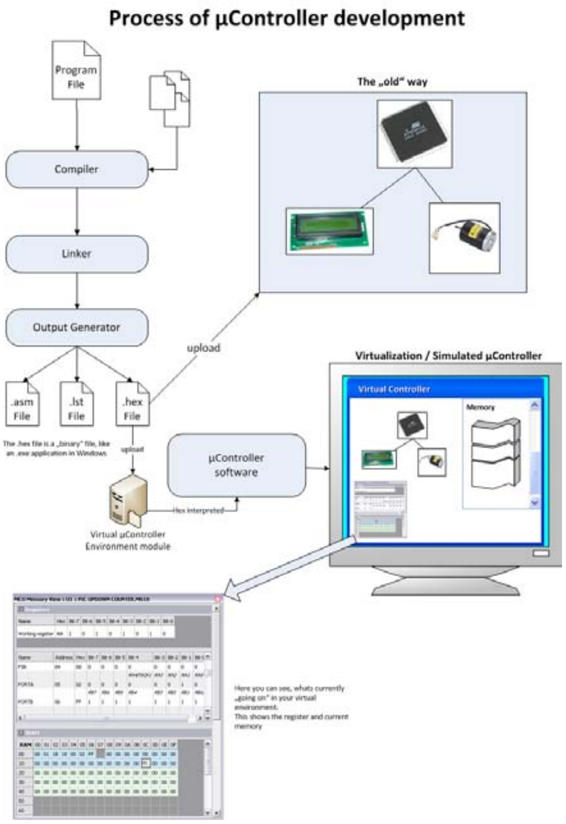

Fig. 2. Process of µController development

To use this framework in studies, handling the virtual components must be very similar to handling real hardware. The idea is that students can develop software using a regular programming tool (like AVR Studio [6]) and run this software on virtualized hardware. Since the software is developed with a standard tool, it will work on real hardware as well as it does on virtual hardware. This way practical experience in programming can be applied to real world problems and applications but don not rely on expensive lab times.

To use a virtual µController framework on the VAP it has to fit following requirements:

1. Modular Architecture. One module for the µController, additional hardware modules that can be connected to the controller. Also there must be a possibility to plug additional modules like a display or a logic analyzer.

2. Open Interfaces. The interface definitions for every module are open. This is the only way to ensure having the framework extensible. To have a platform for further use, it must be possible to develop additional software to support new hardware and chip types.

3. Compatibility to web technology. The virtualized controller and hardware are going to be used on a Web platform.

4. Real Time. The simulation has to run in real time so the virtual µController stays in sync with connected virtual hardware.

During research for this project we looked for already existing solutions that could be integrated into the VAP.

Every component is realized as a webservice that uses a XML file for configuration. This way it can be integrated into the *core platform* easily.

4. SEMANTIC KNOWLEDGE BASE

The Semantic Knowledge Base (KB) approach will enhance the overall system by bringing reasoning with machine readable data to the VAP. It holds interfaces to well-known System Engineering tools like Matlab/ Simulink and implements the SysML [[10]] standard.

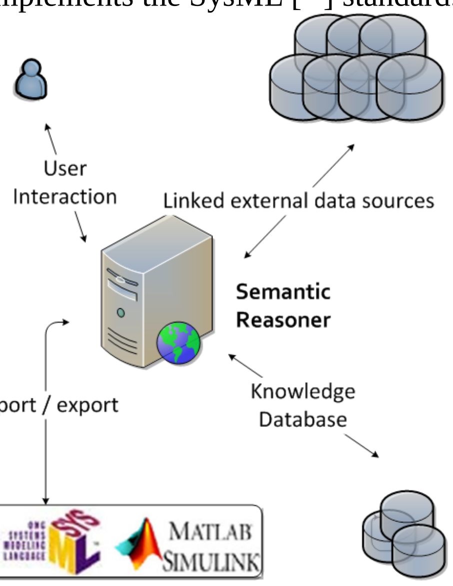

Fig. 3. Semantic Knowledge Base structure

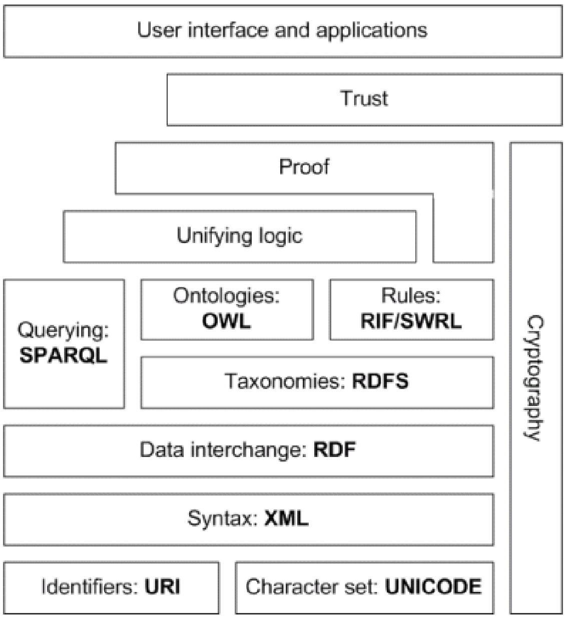

Fig. 4. Semantic Web Layer Cake

Based on collected and annotated data of uploaded material and therefore enriched modules by meta information in XML [7] syntax it is possible to draw conclusions on existing material using Rule Interchange Format (RIF) [8].

By accumulating this data by external linked in data sources it is possible to improve existing solutions in the System Engineering area significantly.
In addition the KB will be supported by system and electrical engineering as well as computer science ontology in OWL [9] to implement the specific technical vocabulary of these sectors. The overall Semantic Web Stack is presented in fig. 4, where the KB is mainly built upon the rules, ontology and querying layers.
The important part of the knowledge base is a model repository, which enables to publish and share the system models and methodology guidelines. A model is created using the software packages mentioned above, enabling to link the simulation model with design candidate. The simulation models can be executed and additional information and behaviour gathered for making the engineering decisions. It is planned to add more reasoning enabling data, like referencing to other KB or implementing additional thesaurus.

5. Hardware Kits

The concept includes in addition to Virtual µController and Semantic KB also the real hardware. The hardware is built up from function based modules forming on that way the mobile kits. Already AVR ATmega microcontroller based kits are developed and successfully tested in the working environment. The latest development is automotive industry oriented hardware kits based on ARM and AVR micro controller platform. These hardware sets are generally refereed as HomeLab Kit. The HomeLab Kit is micro controller-based inter-related set of modules that are completed to a portable case. Various mechatronic experiments and exercises can be carried out with HomeLab Kit, ranging from a simple flashing light to a complex device construction. HomeLab is primarily intended for research and educational institutions, as it includes methodological materials and exercises with solutions in addition to hardware. However the real systems can be easily built with the hardware for the scientific experiments or industrial process control purpose. HomeLab has been integrated into web environment, which is aimed for users to boost interaction between each other and also access to the real hardware over the Internet.
The newest developed solution is HomeLab ARM-CAN Kit which is an advanced solution for building up the controller networks based on CAN or USB data communication protocol. By using the controllers and peripherals it is possible to simulate the modern car, digital factory or robotic system behaviour. The simple user interface equipped with colour LCD and joystick can be used to control the system behaviour and manipulate the process. The simple two node CAN connection is shown on fig. 5. A RC servo motor is connected with one node representing the actuator of

a car. The actuator can be controlled with other node by using on-board button and CAN communication.

Fig. 5. HomeLab ARM-CAN Kit controller boards connected over the CAN interface

The HomeLab ARM-CAN Kit consists of three main controller boards as a nodes and one user interface (see fig. 6). The controller board and user interface has following features:

CAN Controller features

MCU

- Texas Instruments (former Luminary Micro) LM3S5632
- 32-bit 50 Mhz ARM Cortex-M3
- 128 KB flash, 32 KB SRAM
- CAN 2.0 controller
- USB 2.0 host/device controller
- 4 x ADC input (0-3 V measuring range)
- 4 x PWM output (drives up to 600 mA load)
- 2 x CAN connector on 1 bus
- 1 x SPI, 1 x I2C, 1 x UART
- 1 x JTAG (20 pin header)
- 1 x USB device / host (Micro-AB)

Every pin has IO functionality (except PWM) ADC and PWM have 3 pin headers with ground and +5 V.

On-board features

- 1 x Power LED indicator
- 1 x 350 mW RGB LED
- 1 x Push-button

User-interface features

LCD (also used for Nokia 6610)

- 132 x 132 pixels, 4096 colors
- 6 Mbit SPI interface
- StellarisWare Graphics Library driver

Inputs

- 2 axis sliding joystick
- 2 push-buttons

Speaker

- 0.5 W, 95 db, 800 Hz frequency
- Driven by PWM signal with digital amplifier

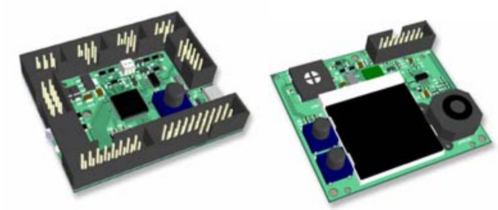

Fig. 6. ARM-CAN controller board and user interface rendered models

6. CONCLUSION

The approach of VAP as a rich internet desktop application will enhance the general educational situation in eLearning by new state-of-the art graphical user interface. Interfacing the different modules allows to easily extending the VAP with new, additional software and hardware solutions. The whole concept described in this paper is a unique new way to exploit new technologies for advanced engineering studies and experiments. It is important to realise that nowadays mechatronic systems are very sophisticated and tightly bundled from electronics and software. On the same time, time-to-market and product development efficiency demands are increased significantly. In this situation the learning process have to be also very efficient but without making compromises in quality and practical hands-on approach. Only way to fulfil these conflicting requirements and reach the young people, is to implement the engineering studies in e-learning environment but not a traditional way. Only newest technology solution on the Internet and combination of hardware kits with remote simulations can satisfy the high needs of engineering study and experiments.

The future development is focusing to include additional interfaces to the system and improve the simulation capabilities together with system models in KB model repository.

7. ACKNOWLEDGEMENT

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