Leveraging Low-Power Hardware to Model-Aided Support of Production Automation Systems (Case Study Pilot for Underground Mine Ventilation)

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***Abstract*—Modeling and Simulation are well-established techniques used in science and technology for prediction, analysis, and evaluation of properties of various complex dynamic systems. The actual trend in the simulation technology is the integration of models into the production automation and control systems, which aims to ensure a higher level of control and a better quality of the decisions made. The model-aided support is of a substantial importance for security-critical systems, such as underground mine ventilation networks, in which the risk of a spontaneous explosion of hazardous gases (like methane) is very high and might cause an enormous damage to human and technical resources. We discuss a possible approach to perform simulation closely to the controlled objects by leveraging low-power, embedded hardware.**

Keywords-Modeling; Simulation; Embedded Hardware;Automated Control Systems; PHANTOM.

I. INTRODUCTION

The high complexity of dynamic processes and their analysis methods require high-performance hardware. In case of big systems, such as the targeted ventilation networks, the use of supercomputers is necessary. However, there are cases in which the simulation should be performed close to the controlled object (an element of the ventilation system). For example, this is required when an emergency situation has happened and the air distribution is being manually controlled by an underground rescue team, e.g. according to a special emergency response plan. In that case, the availability of a simulation platform that would be capable of predicting the development of the air- and gas-dynamic situation based on the current conditions will be of a great advantage and will contribute to the quickest solving of the encountered problem. The goal of this research is to elaborate new concepts for the development of a portable simulation platform to be used in a productional technological environment. The platform should provide support to automated control systems for the case of unexpected events that cannot be handled by the native control systems due to their limited functionality, see Fig. 1. The modelling environment should be designed in a service-oriented way in order to ensure interoperation with the high-performance computing infrastructures whenever a better quality of results is needed.

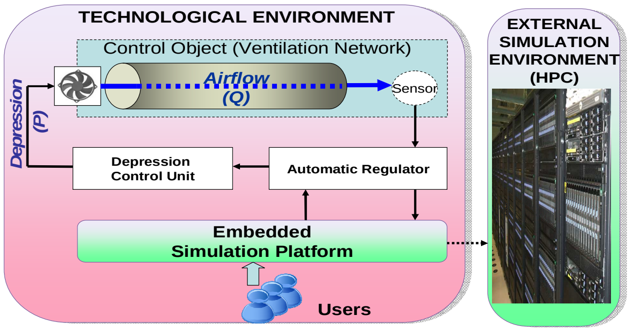
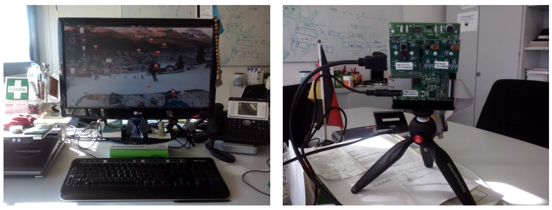


Figure 1. Reconfigurable application example

II. ENVISIONED APPROACH

The use of conventional hardware (Fig. 2a) in conditions of security-critical technological objects is often impossible due to factors like excessive dustiness, humidity, vibration, etc. The energy-efficiency requirements put another strict limitation on the hardware that is allowed to be used. The embedded hardware (Fig. 2b), on the contrary to conventional one, might meet those requirements of the use in the technological environment much better. However, the performance of the embedded systems is lower than of the conventional ones, which requires a trade-off between the required quality and performance of the simulation algorithms on one hand and the capabilities of the hardware platform on the other hand.



a) b)

Figure 2. Hardware platforms for simulation: a) commodity, b) specialized (Movidius' Myriad-2 [5].

The well-established simulation software packages like OpenFOAM [3] are prevalently designed for the conventional (x86 and x64) hardware. The broad spectrum of the embedded hardware platforms (from high-bandwidth microprocessors to SoCs) that is capable of use in industrial conditions as well as their adherence to the RISC (Reduced Instruction Set Computing) CPU architectures prevents the portability of the simulation software to the "light-weighted" hardware.

Cloud computing – the IT organization strategy that was widely established in 2000's – pushed the modeling and simulation community to reconsider their software development approaches towards their brighter service-orientation. The technological foundation for the development of simulation software in a decentralised way has been established, which allows the software components to become interoperable on heterogeneous hardware platforms. Service-oriented development in the form of "microservices" (small interoperable components that implement a specific part of the modeling algorithm, see an example in Fig. 3) seems extremely promising for the next-generation simulation platforms. This, however, requires new approaches to the organization of middleware frameworks for the development and execution of the service-oriented modeling software.

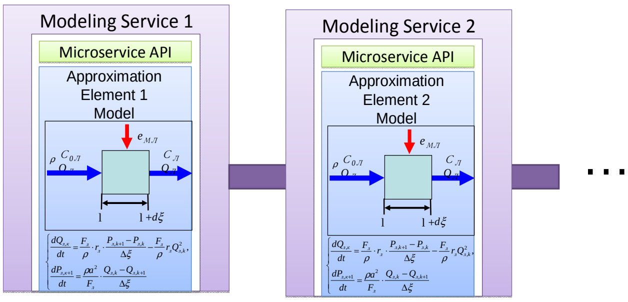


Figure 3. Example of a microservice-oriented simulation framework

III. MAIN ACTIONS FOR FUTURE WORK

The microservice-based approach allows a transition of the already known component-based simulation techniques (e.g. as proposed by Matlab and Simulink [4]) into a modern technological platform, leveraging the advances of the service-oriented Cloud technologies. The challenge of the low-power hardware support is to be tackled by the software compilation and execution technologies developed within PHANTOM [3] – an EU-funded project started in December 2015.

Our goal is to elaborate a **methodology for the development of portable, efficient, and scalable component-based simulation software based on a microservice architecture**. The methodology will be implemented in a software platform for model-aided support of the security-critical technological processes.

We are going to reimplement the available modeling algorithms with the framework we are proposing and evaluate the effects of porting to low-power embedded hardware in terms of performance and power consumption.

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