

ERCIM “Alain Bensoussan” Fellowship Scientific Report

Fellow: **Marek Gayer**
Visited Location : **VTT Technical Research Centre of Finland, Espoo, Finland**
Duration of Visit: **12 months**

I - Scientific activity

During my fellowship, I worked on a project which goal is to create Computational Fluid Dynamics (CFD) modelling software environment, incorporated and cooperating with large scale process simulations, used for process plant simulations, namely e.g. power plants. This CFD environment is designed to be suitable for integration to a large-scale system level simulation tools for industry process simulation of plants, such as Apros 6 software. Large scale steady state simulation can be also combined with steady state analysis with CFD, so integration with steady state process simulators like BALAS is possible.

I concentrated on making prototypes of pre-processing, fluid solver integration, and post-processing. The effort included analysis of state of the existing solutions, selection and realisation of early software prototypes consisting of suitable open-source software component candidates. These prototypes were addressing parts of problems of geometry, mesh, case configuration, boundary and initial conditions, solvers, and visualization parts. I selected VTK visualization toolkit for realization of visualization methods, OpenCascade for working with geometry, OpenFOAM solver for solving fluid problems using finite volume method. The mesh generation is supposed to be provided using NETGEN and snappyHexMesh algorithms and tools.

I have created the proposal implementation based on Eclipse Rich Client Platform in Java and realized with an open platform for interoperable modelling software and components Simantics. I have learned basic concepts and programming techniques to be able to develop my own software components and applications under this platform. The base of the software proposal relies on using semantic ontologies approach and semantic descriptions, which is especially suitable for managing computational model information.

In relation to my exchange programme visits, I have studied OpenModelica, in particular its 2D annotation system, and also OPC UA standard in motivation to integrate and use this standard inside OpenModelica software. These tasks were part of project OpenProd, which is solved at our computer simulation technology team at VTT.

I participated in proposal and implementation of semantic database format for representation of universal finite element meshes suitable for Simantics. The database representation is created from Universal File Format (UNV) using Java parser and Simantics API. The exporters are using Simantics API and are designed to generate input file formats for various finite element method based software and tools, such as I-DEAS, FLUENT, ANSYS, Code-Aster, Salome, Abaqus, etc.

II- Publication(s) during your fellowship

[1] M. Gayer, T. Karhela, and J. Kortelainen, "CFD modelling as an integrated part of multi-level simulation of process plants - semantic modelling approach," in *Proceedings of the 42th Summer Computer Simulation Conference (SCSC'10)*, pp. 219–227, Society for Modeling and Simulation International (SCS), 2010.

III -Attended Seminars, Workshops, and Conferences

- **Finnish OpenFOAM Users Day 2010**, 22.4.2010 - 1 day seminar organized by CSC - IT Center for Science Ltd, Life Science Center, Keilaranta 14, Keilaniemi, Espoo
- **OpenFOAM Basic Course**, 25.5.2010 – 1 day seminar organized by CSC - IT Center for Science Ltd, Life Science Center, Keilaranta 14, Keilaniemi, Espoo
- **OpenFOAM Advanced Course**, 28.04.2010 - 29.04.2010 – 2 day seminar organized by CSC - IT Center for Science Ltd, Life Science Center, Keilaranta 14, Keilaniemi, Espoo
- **Elmer Basic Course**, 25.05.2010 - 1 day seminar organized by CSC - IT Center for Science Ltd, Life Science Center, Keilaranta 14, Keilaniemi, Espoo
- **Elmer Advanced Course**, 26.05.2010 - 27.05.2010 - 2 day seminar organized by CSC - IT Center for Science Ltd, Life Science Center, Keilaranta 14, Keilaniemi, Espoo

IV – Research Exchange Programme (12 month scheme)

1. **Fraunhofer Institute for Computer Architecture and Software Technology FIRST, Berlin, 30. August - 3. September 2010 with Dr. Steffen Unger**, Kekuléstraße 7, 12489 Berlin – Germany, Phone:+49 (0) 30 / 63 92 – 18 00, Fax:+49 (0) 30 / 63 92 – 18

I was learning and discussing about how the working group of Dr. Steffen Unger had so far managed with the problems of static and dynamic 3D graphics annotations for Modelica. I presented our effort done during my staying at VTT, as described in paper [1]. I have also presented effort of our team done within the project of OpenProd and related to our software platform Simantics. I gave the following presentations listed below:

- **a. "Simantics - Open Platform for Interoperable Modelling and Simulation software and components"**

In this presentation, I introduced the flag software platform and product developed by our team for few years in our computer simulation group at VTT, Finland.

- **b. "Videos Open Modelica and System Dynamics in Simantics"**

Simantics software is used also for our efforts with OpenModelica. Videos of two software prototypes made by two members of our team, prototype of OpenModelica in Simantics and System Dynamics tool for OpenProd project with OpenModelica was be presented.

- **c. "OPC Interfaces in OpenModelica"**

Presentation of one of our delivery in OpenProd project, document with analysis "*OPC Interfaces in OpenModelica*", composed by our colleague Tuomas Miettinen. We are exploring and establishing ways to allow to use OpenModelica together with the OPC UA standard. With this approach, OpenModelica can be for example used for simulation aided design and testing of DCS and PLC based control applications in a standard way.

- **d. "CFD Modelling as an Integrated Part of Multi-Level Simulation of Process Plants – Semantic Modelling Approach"**

In this presentation, I introduced my own project, which is software development of Computational Fluid Dynamics simulations integrated and cooperating with large level process simulations. The presentation also explained the most basic, practical concepts and advantages of using Simantics platform and semantic approach in simulation applications.

- 2. **INRIA Paris - Rocquencourt, France, 6. - 10. September 2009 with Yves Sorel, Domaine de Voluceau, Rocquencourt, HdR, BP 105, 78153 Le Chesnay Cedex, France, Tel : (33/0) 5 40 00 21 20, Fax: (33) 1 39 63 51 93**

I was learning and discussing about how the working group of Yves Sorel from INRIA, Rocquencourt, Versailles, had so far managed with the problem generation of optimized code from formally defined models, described by synchronous languages such as Esterel, Lustre, Singal or Statecharts by using special graph oriented methodology and it's sytem level CAD software for the optimization of distributed real-time embedded applications SynDEx. I have presented our effort in the same as in the visit at the Fraunhofer Institute.