Information Society Technologies

Future and Emerging Technologies

COAST

Deliverable 5.3.2

Presentation with project goals and state of the art, publications to the general public and other stakeholders

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Log of Document

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1.1	14-08-08	Input from some partners	A. Hoekstra, UvA
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1.3	19-08-08	Finished draft for internal review	A. Hoekstra, UvA

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Introduction

Coast has produced a plan for using and disseminating of knowledge (deliverable D5.4). The objectives are:

- To share the scientific and technical outputs of the project with the scientific community by publishing in high-impact research publications, international journals and conference proceedings.
- To identify specific research disciplines and industrial and commercial groups for targeted promotional activities.
- To raise awareness of the benefits of the COAST project and its results with these targeted user groups by ensuring that an appropriate message is delivered to each.
- To ensure that specific groups know how they can become involved with the project and its partners.
- To raise awareness of the benefits of COAST to the general public.

The targeted audience of these activities are

- The general public,
- The scientific community,
- Industry,
- Government and Health organisations

The measures for success of dissemination activities include:

- Publication of research results in high-impact international scientific journals, conferences, symposia, and workshops,
- Success of the initiatives for the wider promotion of COAST (media coverage, the number of specialist groups targeted, the number of events where COAST is presented and promoted, website statistics etc.),
- The level of penetration of COAST innovation into the scientific community.

This deliverable reports on the dissemination activities of COAST in the second year of the project.

1 Dissemination Material

So far we have produced three project wide promotional items, a 2-page flyer that describes the project in general terms, a poster, and a more detailed PowerPoint presentation where the project is described in some technical detail. The flyer is the same as last year and was not updated. We have added a general COAST poster. The PowerPoint presentation has been extended with a follow-up presentation describing the main results of COAST after one year.

All items are freely available from the COAST website at http://www.complex-automata.org/dissemination-material. For the reader's convenience we have reproduced the poster in Appendix A (the flyer has been reproduced in the earlier deliverable D5.3.1).

These items are targeted at researchers in the field of modeling and simulation, and to biomedical scientists and engineers. The flyer has been distributed at a number of major events, such as the FET complex systems day in Dresden, October 6, 2007 and the International Conference on Computational Science 2008 (June, Cracow, Poland).

The PowerPoint presentations were used by partners in the project to present COAST on several occasions, such as FET complex systems day in Dresden, October 6, 2007 (collocated with the European Complex Systems Conference), the FET clustering workshop in Brussels, October 2007, IEEE Summer School in Biomedical Engineering held in France 20-29th June 2008, and the Bioengineering Seminar given at Brunel University, London in July 2008

An extensive list of all occasions where the promotional material was used is provided in the appendix of the Periodic Activity Report for reporting period 2.

2 Presence in the popular press

2.1 Scientific Presentations

Partners in COAST have presented COAST related results on many occasions, usually during scientific conferences, seminars and workshops.
An extensive list of all scientific presentations and publications is provided in the appendix of the Periodic Activity Report for reporting period 2 (see deliverable D1.5).

2.2 Industry

On two occasions COAST representatives have met with the R&D project manager of Invatec (www.invatec.com), a successful Italian producer of medical devices in the field of vascular intervention (stents, catheters, etc). At the first meeting, in June 2008, the COAST approach toward modeling and simulation of in-stent restenosis was presented. This resulted in an expression of interest by Invatec. In a second meeting, in August 2008, we explored the possibilities of exploiting the COAST methodology for a number of specific applications suggested by Invatec, and we have explored options for funding joint follow up research after COAST.

2.3 Government and Health Organisations

The 24 September 2007 issue of *The Parliament Magazine*, distributed to members of the EU parliament, the EU commission, and national governments, was dedicated to Health and Research. COAST published a short advertorial into this issue (reproduced in Appendix B).

Over this reporting period we did not explicitly contact Health Organisations. However, USFD will be attending the annual meeting of the ISO Committee on Cardiovascular Devices in September 2008, and on that occasion will disseminate COAST results to a new working group looking at drug delivery from cardiovascular devices.

3 Clustering

Partners within COAST have actively sought interaction with other IST projects.

UvA is partner in the ACGT project, where it is working among others on a cellular automata model of avascular tumor growth. We have started an effort to apply the Complex Automata formalism to the models that are proposed within ACGT.

USFD and UvA have been actively promoting the COAST methodology within the EU ICT-VPH initiative. USFD and UvA are partners in the recently started, EU funded VPH Network of Excellence.

Currently a Marie Curie Initial Training Network is under preparation, dealing with Medical Devices. The COAST multiscale modeling approach, as well as the results with respect to the in stent restenosis will be taken up by this Network.

We have contacted IMAG, the USA NIH Inter-Agency Modeling and Analysis Group. We put details of COAST on their wiki pages (http://www.imagwiki.org/mediawiki/index.php?title=United_Kingdom).

4 Website

The website is regularly updated, with the most relevant additions the dissemination material (as discussed in section 0) as well as lists of published material.

Appendix A: COAST Poster

Complex Automata Simulation Technique for Multi-Scale Multi-Science Systems

DESCRIPTION AND GOALS

The COAST project aims to develop a framework for modelling and simulation of multiscale complex systems.

COAST addresses the multi-scale modelling by using discrete models based on Cellular Automata (CA) and Agent Based Model (ABM), each on different scales. The basic modelling blocks are brought together in a *Complex Automaton*, in order to simulate a multi-scale multi-science process.

COAST is structured along 3 main lines:

- Mathematical formulation of a Complex Automaton, based on a Scale Separation Map and information exchange between different processes.
- Development of a COAST simulation environment.
- Validation using a challenging biomedical application related to coronary artery disease (in-stent restenosis).

A REAL BIOMEDICAL APPLICATION: IN-STENT RESTENOSIS IN CORONARY ARTERIES

A *stenosis* is an abnormal narrowing in a blood vessel. A possible treatment consists of deploying a metal mesh (*stent*) against the wall of the artery. An inflammatory response can lead to a restenosis (figure 2). It occurs in approximately 5-10% of patients following procedures involving stent deployment.

A Multiscale Multiscience Process:

The process can be categorized in various stages:
- initial injury;
- an inflammatory stage;
- granulation,
- extracellular matrix deposition
- finally blood vessel remodelling.

It is a multi-scale multi-science system, covering a range of phenomena from *biology* (cell signaling and cycles), *physics* (haemodynamics, convection-diffusion, transport), *chemistry* (drug uptake, reaction models) and *medicine*, and crossing many orders of magnitude in temporal and spatial scales (figure 1).

Figure 1: Presentation of all relevant processes of in-stent restenosis on a scale separation map inlcuding their mutual couplings

Figure 2: Section of a stented vessel narrowed by restenosis (left) and a typical course of in-stent restenosis (right): before and after stenting, until restenosis appears.

Validation:
The modelling of in-stent restenosis will be used to validate the COAST framework. One of the COAST goals is to develop a series of metrics to facilitate comparison between simulation data and *in vivo* data, in order to tune parameters in biological rule-set using subsets of experimental data.

EXAMPLE OF MULTI-SCALE MODELLING: FLUID-SUSPENSION COUPLING WITH HMC

Modeling of blood flow needs a detailed description of Blood Cells near the vessel wall but only a simplified bulk flow description inside the vessels, plus a proper coupling of these two different scales. Where those domains overlap we can think of a Hierarchical Model Coupling (HMC) [1] approach.

Figure 3: The HMC Suspension Coupling

Figure 4a: General scale map for the automatic proposition of a coupling mechanism. Given a process A, we identify 5 possible regions where another process B can be placed. HMC (figure 3) corresponds to region 3.1.

Figure 4b: Coupling mechanism of execution loops for the HMC suspension example. **D** stands for domain, while **f** denotes the state of the system.

- The middle blue layer (figure 3) holds pressure and velocity fields of a non-Newtonian fluid.
- To obtain an apparent viscosity v(**r**,t) we open up micro-pockets where, receiving as parameters the shear rate and the particle density from the macro-scale, shear flow experiments of fully resolved suspension are carried out, using a lattice Boltzmann approach.
- The macro-scale (yellow layer) resolves advection and diffusion of particles, to address the particle density Φ using the *local* self-diffusivity D and the velocity field u from the fluid layer. This is essential to allow for important effects of complex flow on local particle concentrations and vice versa.

The HMC approach presents an efficient method particularly if numerous other realistic details are incorporated (deformability of particles, varying particle sizes etc.). Instead of costly pre-sampling only relevant regions are sampled and micro-scale simulations are carried out only if interpolation would give insufficient accuracy.

[1] Weinan E and Bjorn Engquist, Comm. Math. Sci. 1(1), 87-132, 2003

COMPLEX AUTOMATA FRAMEWORK

Constructing a Complex Automaton:
Cellular Automata (CA) and Agent Based Models (ABM) are often seen as efficient discrete models for the dynamics of complex systems. They are characterized by an execution loop in form of local collision, propagation and boundary condition operators, which allows particularly favourable and efficient implementations.
COAST will bring together different CA and ABM models on the different scales in a single framework called *Complex Automaton*.

Scale Separation Map:
The multi-scale model is based on a scale separation map (example in Fig. 1), constructed placing the different sub-systems on a Cartesian plane according to their relevant space and time scales. COAST will investigate the different ways of placing a process B relative to a process A on the scale map (figure 4a), the definition of general *coupling templates* (figure 4b) and the consequences on the resulting Complex Automaton, both from the analytical and from the practical point of view.

Simulation environment:
A task of COAST is the development of a general Complex Automaton simulation framework based on JADE, providing elements such as coupling libraries which can be embedded into different existing software, in order to allow a wide range of applications.

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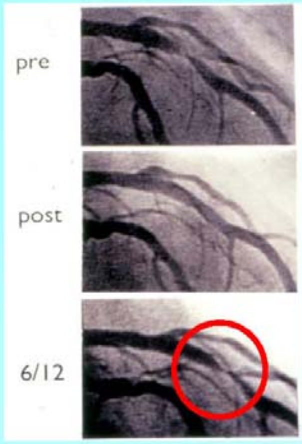
Appendix B: COAST Advertorial

- *Complex Automata Simulation Technique*
- *EU-FP6-IST-FET Contract 033664*
- www.complex-automata.org
- Project leader : Dr. A.G. Hoekstra, University of Amsterdam (alfons@science.uva.nl)

- Modeling aspects of **Coronary Artery disease**.
- "For me, COAST represents a fantastic opportunity to marry the awesome capabilities of computer modeling to one of the major health problems of our time - namely coronary artery disease; and, in particular, the response of the coronary artery to one of the commonest forms of treatment now used across Europe - stent insertion. Never before have we been able to turn such powerful analytical techniques to the further understanding of the biology of the arteries within the human heart that convey the blood vital to our survival" *J.P. Gunn, Cardiologist at the Sheffield Teaching Hospitals, UK.*
- Simulating the process of in-stent restenosis leads the way to the next step, computer aided design of more advanced stents.
- The societal impact could be substantial. Coronary artery disease is the major cause of death in the Western World. The associated costs are estimated to be €45 billion Worldwide/year.



Images depicting restenosis in a Coronary artery. "Pre" and "Post" are before and after stenting, and 6/12 is 6 months later, showing in-stent restenosis