Simulation for the Future: Progress of the Esprit Basic Research Working Group 8467

Hans L. Vangheluwe, Ghislain C. Vansteenkiste
Applied Mathematics, Biometrics and Process Control
University of Gent
Coupure 653
B-9000 Gent
Belgium

Eugène J.H. Kerckhoffs *
Applied Mathematics and Informatics
Delft University of Technology
Julianalaan 132
NL-2628 BL Delft
The Netherlands

tel: +32 (9) 264 59 37
fax: +32 (9) 223 49 41
e-mail: SiE@hobbes.rug.ac.be

Abstract

The Esprit Basic Research Working Group 8467 on "Simulation for the Future: new concepts, tools and applications", with the acronym SiE-WG (Simulation in Europe - Working Group), started its work on December 1, 1993. It was an initiative of the SiE-SIG (Special Interest Group), currently consisting of some 150 industrial and academic members. The SiE-SIG acts as a platform and validating forum for SiE-WG results. The –now concluded– first phase of the SiE-WG activities was one of meta-research and focusing. From the vast arena of modelling and simulation, specific topics were selected which are deemed crucial for the future. Research into these topics now receives sponsoring of the SiE-WG. Action clusters of particular relevance to European industry and to the end-user were defined. Within these clusters concerted research now takes place (with SiE sponsoring meetings).

The history of SiE is presented as well as the methods used to come to concrete Basic Research actions. The conclusions of the focussing phase of SiE's activities are presented in detail.

Special Interest Group SiE-SIG

In January 1992, the Special Interest Group "Simulation in Europe" (SiE-SIG) was established. This was a direct result of the increasing need for computer simulation, its multidisciplinary aspects and a joint industry/academia interest. One of the aims of SiE-SIG's establishment was to draw the attention of the Esprit officials to introducing simulation in Esprit Workprogrammes and encouraging its members to submit Esprit project proposals. On the basis of SIG discussions "Simulation Policy Guidelines" were formulated:

1. Improve the modelling and simulation process
   (a) Modelling:
   Redefine "modelling" in a broader perspective than currently used and exploit this as a basis for new modelling and simulation methodologies (i.e., *multi-paradigm systems*). Focus on generic (e.g., object-oriented) component modelling and supporting representations to enhance re-usability and portability of existing and new simulation models.
   (b) Techniques:
   Adapt Software Engineering and Artificial Intelligence methods and tools (e.g., formal verification, re-use, version management and decision support) to modelling and simulation problems. Merge results in integrated methods and tools (e.g., *multi-language software systems*).
   (c) Life-cycle:
   Attention to the full Modelling/Simulation Experimentation/Validation life-cycle. Explicit description and prescription of this (possibly concurrent) life-cycle to improve quality of the end-products (software and/or hardware).
2. Open new application areas
   (a) Include new peripheral devices and novel algorithms into simulators. Enter new application areas (for example, in the medical sector).

* Currently part-time professor at the University of Gent

(b) Exploit *highly parallel* hardware architectures to simulate *multi-component* systems by directly mapping model structure onto hardware structure.

3. Provide user-simulator interfaces

   (a) Provide a common basis for independent development of simulators and user-interfaces by means of Open Systems (e.g., PCTE).

   (b) Intelligent user-simulator *interfaces* should present multiple interaction scenarios to simulation information (e.g., education by simulation, assisted statistical *interpretation*). "User Centered" interfaces necessitate integration of both engineering and human science models.

4. Enhance awareness (through knowledge dissemination)

   (a) Provide *education* in Modelling and Simulation to remedy the skill shortage in this field. The education (both in universities and onsite) must be tailored to the end-user needs. The implementation of a "virtual" center for simulation studies by means of an education *network* seems most appropriate.

   (b) Disseminate information about simulation as well as standardized tools to current and potential simulation beneficiaries. Both traditional (mailing and meetings) as well as innovative (network servers and electronic discussion boards) communication means can be employed.

5. Prepare standards and standardization procedures . Support flexibility in design and reusability of models by developing general formats for the information base of models in different application areas.

SiE-SIG decided to incorporate subject 5 into the subjects 1 and 3 and to stress the multidisciplinary aspect by formulating major application areas to focus on: *manufacturing, control, training, construction and design, bio-engineering.*

Esprit Basic Research Working Group SiE-WG

In the Esprit 1993 Call for Proposals, the R&D priority themes were formulated for the Basic Research programme. It was found that a good *match* exists between the priority themes 1-3 of the Esprit Basic Research programme and the first 3 subjects of the SiE-SIG's Policy Guidelines mentioned above, where key words common in both programmes are *emphasised.*

Based on the above matching of the SiE-SIG's Simulation Policy Guidelines and the Esprit Basic Research Priority Themes a proposal was submitted (initiated by SiE-SIG) to the European Commission to establish an Esprit Basic Research Working Group. The proposal was accepted. The official name of the Working Group is: Esprit Basic Research Working Group 8467 on "Simulation for the Future: New Concepts, Tools and Applications" with the acronym SiE-WG. The list of participants of SiE-WG consists of the contractor (the University of Ghent, Belgium) and 23 associated (academic and industrial) partners from all over Europe. SiE-WG works in close cooperation with SiE-SIG. In fact, SiE-SIG is a platform and forum for SiE-WG, where activities of SiE-WG are initiated and results and follow-ups are discussed; SiE-SIG is a *ruling body for eventual industrial applicability.* Currently, the SiE-SIG consists of some 200 partners from industry and academia.

The official starting date of SiE-WG was December 1, 1993, and the duration of SiE-WG's working period is 3 years. During this period, the Working Group operates as specified in the Technical Annex of the contract with the European Commission. The programme of work in the 3-years period is subdivided in two phases of 1.5 years each. Phase 1 is a transition phase and a phase of meta-research (determining critical subject areas), which has resulted in the detailed specification of phase 2 in which SiE-WG operates as a normal WG as meant in the Esprit Basic Research Workprogramme (actually performing Basic Research). In phase 1, the SiE-WG has 3 themes to focus on (in correspondence with the first three subjects of the SiE-SIG Simulation Policy Guidelines):

Theme 1: Improvement of the modelling and simulation process (issues of interest are a.o. multi-paradigm modelling concepts, multilanguage software systems, combined discrete-continuous simulation).

Theme 2: New application areas, especially underlying techniques (issues of interest are a.o. parallel and distributed simulation, simulation of multi-component systems).

Theme 3: User-simulator interfaces (issues of interest are a.o. intelligent interfaces, animation, scientific visualisation).

Strategic Decisions

A number of queries amongst the European Simulation Community as well as two intense workshops have led to the definition of subject clusters and tasks which are deemed relevant to the competitiveness of European companies. This competitiveness is however achieved through openness and adopting of standards. Interested parties world-wide (not restricted to Europe) are encouraged to contribute.

Subject clusters:

A. Modelling (model specifications at low to high level)
The representation of models of complex systems needs the support of:

- a multi-paradigm methodology, allowing the modeller to express model knowledge using a blend of different abstract representations (rather than inventing some new superparadigm).
- tool and vendor independent, neutral languages to represent model information.

B. Simulation (speed, accuracy, interactivity and self-documentation)
The actual "execution" of models, which provides quantitative insight into the behaviour of the modelled system needs the support of :

- a neutral model representation at execution level. An abstract model should be translated to a tool and vendor independent executable representation.
- a communication protocol which defines interaction between simulators in a tool and vendor independent manner. A particularly interesting sub-topic is the protocols for networked simulator operation.

C. Human Computer Interaction (assisting interfaces):
During the Modelling and Simulation process, be it for analysis, design or control purposes, the user interacts continuously with Modelling and Simulation tools. It is crucial to evaluate the quality of the tools (and underlying methods and techniques) from the point of view of the end-user. Rather than developing new User Interfaces, focus should be on the construction and application of different quality metrics for User Interfaces from the viewpoint of the Modelling and Simulation practitioner.

Tasks:

1. Present and future ; state of the art ; classification
The analysis of State of the Art realisations should be done in an end-user driven manner. Complementing a theoretical analysis of "what is best" or "what is most elegant", the end-user should drive research into Modelling and Simulation of the future. A concrete task consists of interaction with end-users (through interviews etc.) to determine their needs. This to avoid at all cost, divergence between SiE-WG Basic Research activities and the actual current and future needs of the users.

2. Future methodology development needed
The development of a methodology, methods and techniques is required. Within such a framework (generic architecture), standards and eventually applications can be developed.

3. De facto standards ; new practices
The convergence towards standards. Standardisation increases interoperability and can drastically reduce the complexity of problem solutions. The SiE-WG standardisation efforts should consist of specifications accompanied by small benchmark implementations. An organic evolution towards de facto standards is preferred over a rigorous standardisation procedure.

4. Industrial demonstrators ; model accreditation
Industrial demonstrators and validators are essential for the credibility and usability of any SiE-WG effort. Verification, Validation and Accreditation of simulation models and their implementation as well as application need to be investigated.

5. Exploitation plans; future needs of end-users
Exploitation plans of all of the above need to be considered. This again refers to end-user involvement. If no exploitation plans can be deployed, there is obviously no real need for the development. Bear in mind though that SiE-WG is a Basic Research working group, which should come up with solutions for the future (not only for short term needs). Hence, the end-user may have to be made aware of some of their future needs.

Research Action Recommendations

From the reactions of the SIG, Basic Research *Action Clusters* were identified. These are *subject-centered activities*, partially sponsored by the SiE-WG.

As a general conclusion, there is most active interest in subject A (Modelling). This not only indicates the need for insight, development and standardisation in model specification, but also the dependency of subjects B (Simulation) and C (Human Computer Interaction) on developments in model specification. Thus, the main focus of the current SiE-WG Basic Research Activities is on Modelling. Future activities will deploy results in Simulation and Human Computer Interaction.
Specific topics of SiE-WG interest are also addressed in the Simulator Interoperability Working Group (SiWG) (related to subject B) and the Human Comfort and Security activities of the EC (related to subject C). SiE-WG aims to actively contribute to both with its current modelling research. Obviously, activities will span the full tasks (1-5) spectrum.

Action Clusters:

1. Multi-Paradigm Modelling

- It is recommended to establish a *Language Standardisation Committee* with academics, software developers and end-users. With respect to multi-paradigm and heterogeneous modelling, we need to be precise; we need *glossaries, vocabularies, descriptions, definitions and standards.* The key issue is the *semantics* of models.
- Development and demonstration of a *neutral model format* which allows object-oriented system definition, and deducing all the pertinent data for multi-paradigm modelling. A basis for that shall be NMF, Dymola, PROFORMA, ALLAN, ULM, VHDL-A, ... For model data exchange, links to STEP and Express shall be established.
- An area of particular interest (mainly from an industrial point of view) is the "symbolic manipulation" of continuous models to enhance re-usability and simulation run-time performance. It is recommended to start a *Symbolic Manipulation Committee* to coordinate developments and dissemination.

2. Simulators and low-level model representation

- Development of *standardisation guidelines* which identify needs and a generic architecture for simulator-level model exchange.
- Development and demonstration of a *neutral simulation model protocol* taking into account real-time execution requirements. A basis for this shall be DSblock for continuous modelling and openDEVS for discrete event modelling.

3. Simulator Interoperability

It is the task of SiE-WG to distribute *knowledge* regarding Distributed Interactive Simulation (DIS). For this purpose, SiE will collaborate with SiWG (Simulator interoperability Working Group). To ensure DIS is *usable* and can *be adopted.* To *advocate*, develop and illustrate the concept of Synthetic Environments. The underlying rationale is to *get it right the first time* in product development. That is, to use simulation to develop virtual products in virtual environments to avoid mistakes or sub-optimal solutions. The deliverable will be a *white paper on Simulator Interoperability* and its *application* to the Virtual Enterprise.

4. Industrial Demonstrator Deployment

- The development of an *Industrial Demonstrator Deployment Handbook.* This handbook will give guidelines on the meaningful deployment of Modelling and Simulation Methods, Techniques and Tools.
- The implementation of a *demonstrator.* The demonstrator shall illustrate the validity of multi-paradigm modelling.
- *Validation* by industry and end-user of the above demonstrator.

5. End-User Involvement, User-Simulator Interfaces

Interface development should not only be focussed on *technical aspects*, but take into consideration *ergonomics* and *cognitive sciences* issues. The rationale for this is that one needs to start by studying the *user's problems* and needs before delving into technical problems. The user needs must be *real* end-user needs, rather than potential expectations of virtual end-users !

Application-driven Human-Computer Interaction Quality Evaluation: to establish a Human Computer Interface *evaluation group* in the specific context of (computer aided) modelling and simulation. This group will build an *evaluation methodology and techniques* to identify the *quality* of HCI *prototypes.* The deliverable shall be an *evaluation handbook.*

Technology-driven Human-Computer Interaction Design and its relation to System Models: *map system models* (structure, behaviour) onto *user requirements.* Essential in this is to identify user requirements (possibly through a "user model") and the relation of these requirements to the system model. To build a *design methodology* and techniques for modelling and simulating *real-world systems*. The deliverable shall be a *design handbook*.

The link with multi-paradigm modelling is seen as a framework for attaining the above goals.

6. Additional Actions
SiE-WG has to disseminate knowledge to enhance the awareness of simulation capabilities.

The above Action Clusters form a basis for the selection of the appropriate European research institutions and laboratories (inside and outside the current Working Group), which participate in the Basic Research.

Operation

To maximise the efficiency of Basic Research activities in the areas identified in the first phase of the SiE-WG operation (the above Action Clusters), the following *practical* decisions were made:

- A small number of "demonstrator" projects are implemented.
- For most of the Action Clusters, a task force of experts is being formed which discusses its subject intensely via electronic means.

The deliverable of the activities will be a "white book" on the Action Cluster subjects presenting the current state of the art and future directions in research.

An overview of SiE activities is depicted in figure 1. Beside the life of SiE-SIG and SiE-WG, it also shows the spin-off in the form of EC and other projects. It is felt that the focussing part of SiE's activities has brought together researchers and those who apply research results. In particular, the evolution towards standards is spawning a plethora of activities.

You are invited to actively contribute to these activities. Contact `SiE@hobbes.rug.ac.be` or look at `http://hobbes.rug.ac.be/SiE/` for a detailed overview of current and past activities. Also, it contains directions on how to join the SiE-SIG.

References

[1] E. Kerckhoffs, H. Vangheluwe, G. Vansteenkiste (eds.), *Progress Report 1994, Esprit Basic Research Working Group 8467,* Coupure 653, B-9000 Gent, Belgium.

[2] E. Kerckhoffs, H. Vangheluwe, G. Vansteenkiste (eds.), *Progress Report 1995, Esprit Basic Research Working Group 8467,* Coupure 653, B-9000 Gent, Belgium.

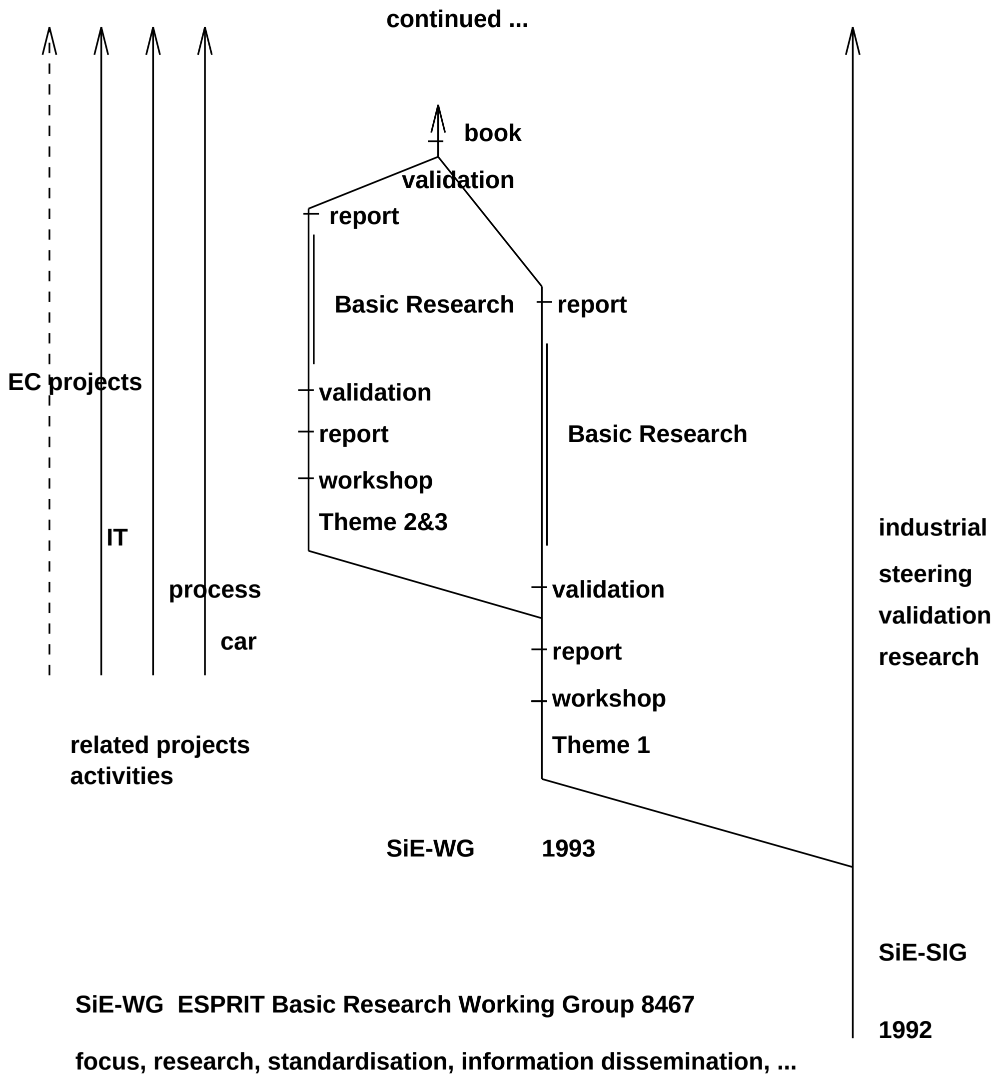

Figure 1: SiE-WG timescale