HARD AND SOFT APPROACHES IN A SIMULATION META-METHODOLOGY

László Muka
Elassys Consulting Ltd.
Bég utca 3-5.
H-1026 Budapest, Hungary
e-mail: muka@t-online.hu

Gábor Lencse
Department of Telecommunications
Budapest University of Technology and Economics
Magyar tudósok körútja 2.
H-1117 Budapest, Hungary
e-mail: lencse@hit.bme.hu

KEYWORDS

simulation methodology, simulation meta-methodology, hard method, soft method, collaborative modelling, organisational information and communications systems, business process system

ABSTRACT

A simulation project for Information and Communication Technology (ICT) system design and Business Process (BP) design in an organisation usually starts with an unstructured problem situation. We have already outlined a simulation meta-methodology addressing the situation. Now, we give a detailed description of the proposed simulation meta-methodology dealing with both the hard and the soft aspects of the problem. We describe the detailed process and functioning of a hard six-step simulation methodology which is an integrated part of our simulation meta-methodology.

We define the role of the traditional SSM (Soft Systems Methodology) in the simulation meta-methodology, and also show how our previously proposed Soft Systems Methodology with Modified Conceptual Models (SSM-MCM) can function as a bridge between hard and soft approaches. There is also introduced a new fast simulation approach, based only on the Traffic Flow Analysis and the Entity Flow-phase Analysis.
We also examine the functioning of the simulation meta-methodology in a collaborative environment, which is a frequent situation.

INTRODUCTION

A simulation project for Information and Communication Technology (ICT) system design and Business Process (BP) design in an organisation usually starts with an unstructured problem situation.

In a situation like this, there is a need for using a methodology which is able to deal with both the unstructured, soft aspects and the hard aspects of the problem, thus this methodology has to integrate the soft and hard approaches.

In (Muka and Lencse 2006) we outlined a simulation meta-methodology addressing these requirements: we proposed a simulation meta-methodology supporting problem-structuring and effective goal definition, also increasing efficiency by precise localization of systems to be modelled and by supporting decisions on the use of parallel simulation helping in speeding up the simulation.

In (Muka and Lencse 2006) we introduced new concepts to SSM (Soft Systems Methodology, Checkland 1985, 1989), hardening-up the traditional SSM ((Gregory 1993) and (Jackson and Keys 1984)). Our new concepts, Soft Systems Methodology with Modified Conceptual Models (SSM-MCM), help in the analysis of the organisational information systems and also give support to timing decisions in modelling.

In this paper we give an exact definition of the elements and cycles of the outlined simulation meta-mehodology.

We also describe a new approach of the preliminary modelling step, a method, using only TFA (Traffic Flow Analysis) and EFA (Entity Flow-phase Analysis) for this purpose.

In this paper we also introduce how SSM-MCM functions as a bridge between soft and hard approaches and we exactly define the functions of classic SSM in the process of the simulation meta-methodology.

In (Muka and Lencse 2006) we proposed a six-step hard simulation methodology to the simulation meta-methodology.
Now, we give a detailed description of the proposed hard methodology, introducing the working process and describing the functions of the hard simulation methodology.

Finally, in this paper we also examine the simulation meta-methodology process in a collaborative environment, which can be a usual situation, by comparing meta-methodology to a multi methodology, using the approach described in (Sierhuis and Selvin 1996) and (Sierhuis and Clancey 2002) as a starting point.

DETAILS OF THE SIMULATION META-METHODOLOGY

In this paper we examine how the simulation meta-methodology works in detail.

First, we introduce the hard and soft approaches used in building the meta-methodology.

Hard Approach: Detailed Formulation of the Proposed Six-step Simulation Methodology

Traditionally, *simulation* is considered to be a *hard systems approach* as a typical *predict and control method* (Jackson 1991).

As an element of the *simulation meta-methodology* (MM) we describe in detail a hard *simulation methodology* (SM) comprising six steps.

The six-step process of SM is shown in Figure 1.

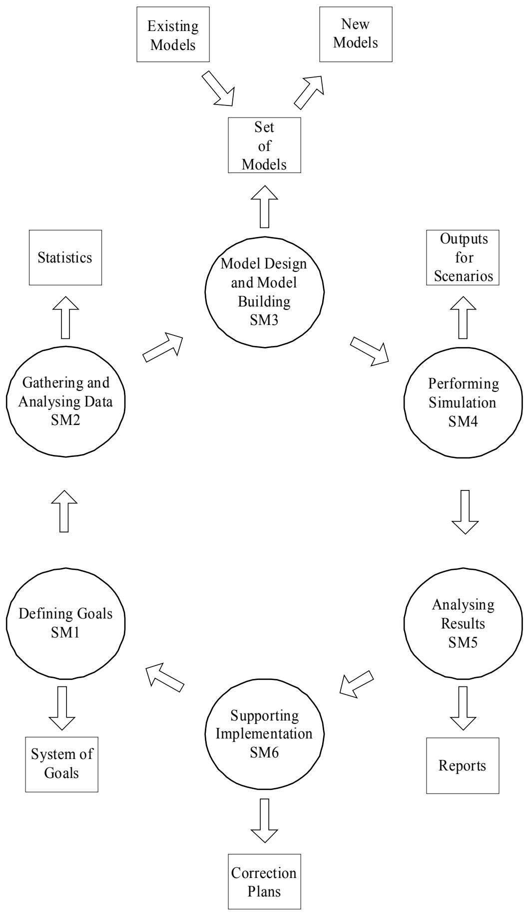

Figure 1.The Six-Step Process of the Proposed Classic Simulation Methodology

This is an iterative approach where an *implementation support step is closing the loop*. SM can be applied to simulate both P and IT elements of an organisational information system (Muka and Lencse 2006).

<u>SM1 Defining Goals:</u> - including preliminary design of models

At this step we define the goals of the simulation: the features to be simulated, the resolution and interval of simulation.

A preliminary model design (which should be a simplified and fast model design and simulation) serves to help successful goal definition by giving a general view about the model and the simulation. The result is a *System of Goals* containing also the relationships of goal elements.

<u>SM2 Gathering and Analyzing Data:</u>

Here all the data necessary for simulation should possibly be collected: data about the "as-is" state and the states *"before-the-as-is"* of the systems to be simulated for a reasonable time interval and scope. It should be a thorough *data mining* activity: we should try to find data about the normal and the extreme modes of operation, and if there is any information about disasters and disaster recovery situations.

The preliminary simulation model mentioned in SM1 may help to find the right data and the correct limits to data gathering.

Here we should find all the input data for simulation, data about the model intended to be built and its loads.

The collected data should be analyzed and the *Statistics* produced to help the necessary understanding of the systems.

<u>SM3 Model Design and Model Building:</u>

This is a tool-specific step: in many simulation environments (like ARIS, System Architect, Brahms, etc.) there can be a separate step of designing a formal, *static* model. In other environments design and building of simulation models is performed in one step. It is the direct *dynamic* approach (see Simprocess, ImiNet, ImiFlow, etc.).

According to the defined goals usually a *Set of Models* is designed and built. To improve efficiency, *Existing Models* can be used but usually it is also necessary to design and build *New Models*.

<u>SM4 Performing simulation:</u>

This is also a tool-specific step and closely related to SM3.

At this step, run-analyze-debug cycles are performed and as a result we will have model-runs of validated and verified models.

According to SM1 a set of "as-is" and "what-if" scenarios are examined and the required *Output for Scenarios* is produced.

In a hard approach, the decision about parallel simulation is usually made at this step: the only criterion to use parallel simulation is the software-hardware capacity limit sufficient to perform the simulation with the required features.

<u>SM5 Analyzing Results:</u>

At this step, a *data mining* activity is also required because of the usually large quantity of output data. It may happen that we have got the necessary results but we cannot find them. The other important requirement is the *visualization* of the results (In visualization, the *animation* feature of our tool may have importance.). Using data mining and visualization in the analysis we produce *Reports* about the simulation for the defined users of the results.

<u>SM6 Supporting Implementation:</u>

This is an unusual step in the methodology but it may be useful to consider the implementation aspects immediately. It may reveal the necessity of producing *Correction Plans*, because there can be different alternatives in the steps and timing of implementation. It may be useful to perform SM6 in a preliminary way and include it into *Reports* produced at step SM5.

Soft Approach: Two Aspects of Using SSM in the Simulation Meta-Methodology

The classic SSM is a soft approach. In MM two different aspects of SSM are important:

1. SSM as a learning method
2. SSM as a method for information system analysis and design

1. SSM as a learning method plays multiple roles in MM:
    a. It is a method of facilitation in the team work
    b. It is a method of enquiry
    c. It is a method of consensus building
2. The modified SSM, that is SSM-MCM (Soft Systems Methodology with Modified Conceptual Models (Muka and Lencse 2006)), is a soft method that has been *hardened up* (Jackson and Keys 1984) to support information system analysis and design.

The Simulation Meta-Methodology: Elements and Cycles

In the following, we describe the elements and cycles of the MM using the concept of combined hard and soft approaches introduced in (Muka and Lencse 2006).

(The elements and cycles in working process of MM are shown in Figure 2.)

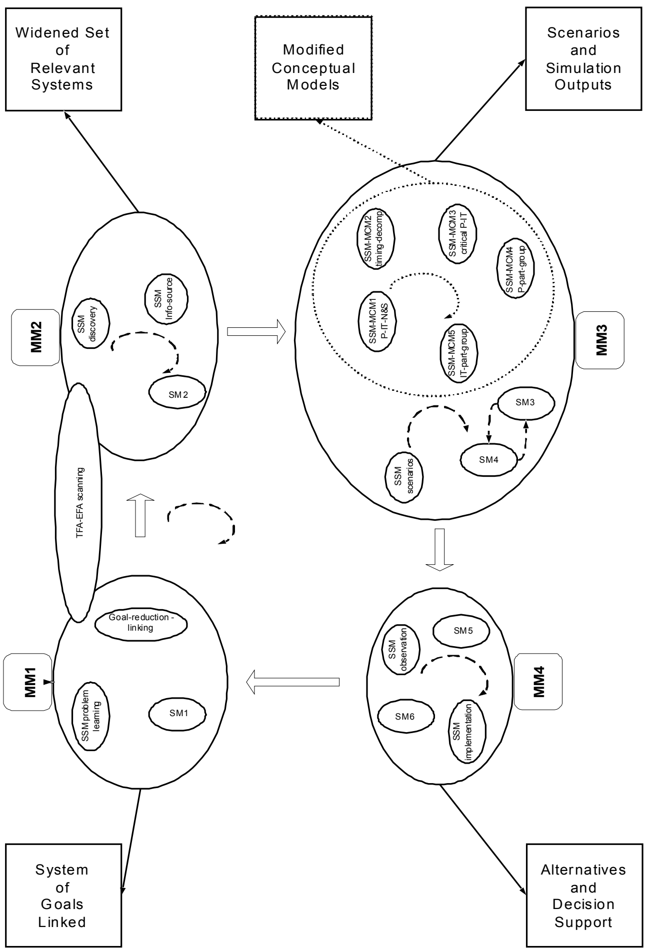

Figure 2. Elements and Cycles of the Meta-Methodology

Main points of MM are as follows:
MM1: Goal Definition
MM2: Identification of a Widened Set of Relevant Systems
MM3: Development of Conceptual Models and Simulation
MM4: Analysis and Support for Implementation

Now let us consider the detailed work of MM:

MM1 consists of the following elements: SSM problem learning, Goal-reduction-linking, SM1 and TFA-EFA scanning.

SSM problem learning: a classic SSM is used for learning the situation, learning the goals and their relationships for the derivation of requirements for simulation models.
Goal-reduction-linking: this is a hard element, a method of getting the simulation project goals from the organisational goals. The basic idea of this method is the goal reduction (Koubarakis and Plexousakis 1999) and linking the goals to the processes to be simulated and to the process of the simulation project itself.
SM1: Defining goals
TFA-EFA scanning:
By performing this methodological element, we execute preliminary simulation. At this step, we do not want to get exact final results but rather to see the quality and scope of the results, to introduce the simulation method, to get information about the necessary inputs, and to get information about the future models and simulation, in order to help goal definition, and to make the objectives clear.

For this purpose *fast full MM cycles* are to be used that is fast cycles including MM1-MM4.

To perform fast simulation in this phase, methods like EFA and TFA may be efficient (Lencse and Muka 2006a, 2006b). (As an additional advantage, models constructed at this step may be used later in the methodology at phase MM3.)
(For further research it may be fruitful to examine the use of the Statistical Synchronization Method (Pongor 1992) (Lencse 1999) as a fast simulation method at this step of MM, because of its minimized communication needs between model segment.)

MM2 contains: SSM discovery, SSM data source, TFA-EFA scanning, SM2.

SSM discovery: This is a classic learning SSM, whose purpose is to identify all the systems possibly influenced by the simulation project, to gather and analyze informal data too, to identify the widened set of relevant systems.
The widened set of relevant systems consists of systems that are sources of data for simulation, systems that can be probable users of simulation results, and systems probably to be simulated.
SSM info-source:
This is a classic learning SSM used in order to identify formal and informal data sources and also to identify typical and critical data configurations.

The method supports identification of typical and critical data configurations for all relevant systems. These data configurations should be identified for the simulated time interval, or for a reasonably longer interval having influence on the simulation.
TFA-EFA scanning: The purpose of using the method is to help data source identification and to find the users and potential users of data in order to maximize effectiveness and efficiency of simulation project.
SM2: Gathering and Analyzing Data – It is a method of gathering and analyzing *formal* data.

MM3 consists of elements: SSM scenarios, SSM-MCM1 P-IT-N&S, SSM-MCM2 timing-decomp, SSM-MCM3 critical P-IT, SSM-MCM4 P-part-group, SSM-MCM5 IT-part-group, SM3, SM4.

SSM scenarios: This is a learning SSM to identify simulated scenarios and also to verify and validate simulation models.
SSM-MCM(1-5): These SSM methods are using MCM (Modified Conceptual Models) introduced in (Muka and Lencse 2006).

- SSM-MCM1 P-IT-N&S: to identify P and IT subsystems, and elements to N&S conditions
- SSM-MCM2 timing-decomp: to define time relations in models, to synchronize models and to make time decomposition
- SSM-MCM3 critical P-IT: to define critical P and IT elements to be simulated
- SSM-MCM4 P-part-group: to make decisions on partitioning and grouping of P elements for *parallel simulation*
- SSM-MCM5 IT-part-group: to make decisions on partitioning and grouping of IT elements for *parallel simulation*

Considering the application of parallel discrete-event simulation (PDES) we make decisions about grouping or partitioning the elements and also (already having the information about critical elements) we may have considerations about using DES-P DES-IT, TFA and EFA and also about using the combination and interworking approach in parallel simulation (Lencse 2004), (Lencse and Muka 2006a), (Muka and Lencse 2006).
If a subsystem seems to be too large we may try to use expansion for partitioning (Muka and Lencse 2006). After PDES decisions the simulation elements SM3 and SM4 are completed. At performing SM4 it may be necessary to reuse the SSM scenarios method.
SM3: Model Design and Model Building
SM4: Performing Simulation

MM4 has elements: SSM observation, SM5, SM6, SSM implementation.

SSM observation: This is a learning SSM application helping in the evaluation of the simulation results we got from performing SM5. Based on formal information of the analysis in SM5 and on informal assessment of SSM, alternatives for decisions can be made.
SM5: Analyzing Results
SM6: Supporting Implementation
SSM implementation: This is a learning SSM application which is used in the evaluation of implementation features revealed by SM6. To complete a successful simulation project, it is advisable to close the methodological loop and to think about implementation aspects as a decision support element.

The Simulation Meta-Methodology and the Organisational World

In Figure 3. we show the simulation meta-methodology with its elements and their relationship in the Organisational World, in the world where the simulation takes place and where the meta-methodology should work.
The organisational world is divided into two parts: the Hard Thinking World and the Soft Thinking World.

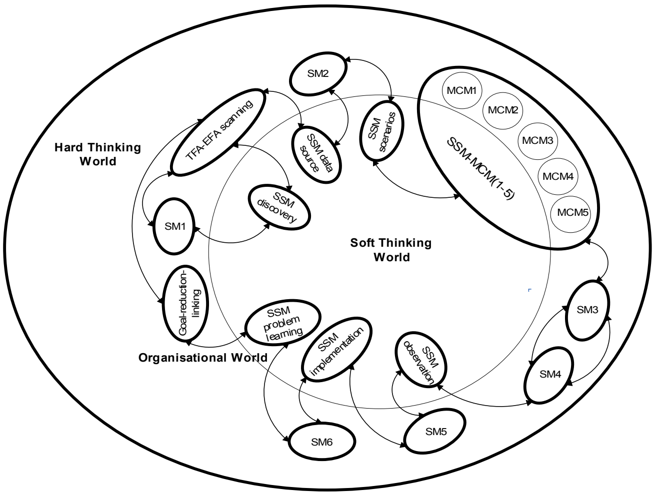

Figure 3. Hard and Soft Thinking in the Process of the Meta-Methodology

The conclusions may be the following:

- the classic SSM works in Soft Thinking World
- the SM woks in the Hard Thinking World
- the SSM-MCM works "between the worlds"
- the MM cycle starts and ends in Soft Thinking World
- usual soft and hard methods have only logical connections: after completing their cycle we go on to use the next method
- in the case of SSM-MCM hard steps are introduced into the soft cycle therefore it operates in a transient way.
- the starting and finishing method (SSM problem learning) is in the Soft Thinking World

ANALYSING SIMULATION META-METHODOLOGY AS A COLLABORATIVE APPROACH

A description of a *framework for collaborative modelling and simulation* was given in (Sierhuis and Selvin 1996) and (Sierhuis and Clancey 2002). The *collaborative modelling and simulation process* is viewed as a *holon* in the sense of

Soft Systems Methodology. (*SSM type holon* is a particular kind of holon, a Human Activity System (HAS), that is a set of activities connected to make a purposeful whole (Checkland and Scholes 1990).) In this approach there are two design teams - a soft thinking team and a hard thinking team – and there is a *multi-methodology* that consists of methodologies M1-M4. (Any of the methodologies are also holons in this framework.)

Now we will summarize the features of the methodologies in the *multi-methodology*:
M1 is a methodology to perceive a system and to construct soft static models. This is a structured methodology to observe and analyze the "as-is" state of the system (or problematic situation) with the goal to gather data describing the system.
M2 is a methodology to design simulation models.
This is a methodology to co-design formal static models, to translate soft models into formal models.
M3 is a methodology to create and to run simulation models. This is a tool-specific methodology to implement, to debug, and to validate dynamic simulation models and to run the simulator with the formal model as input, and the dynamic performance (behaviour) of the simulated system as an output.
M4 is a methodology to observe the simulation output. The purpose of this methodology is to observe and to investigate simulation results by comparing the results with the existing system in order to create shared understanding of the system.

For our analysis, we ***modify*** the *collaborative modelling and simulation process* described in (Sierhuis and Selvin 1996) and (Sierhuis and Clancey 2002).

The modifications (shown in Figure 4.) are summarized in the points below:
1. The analyzed HAS is an organisational information system with P and IT elements in it. (The *Organisational Systems* with P and IT elements that are in the focus of our analysis may also be viewed as holons.)
2. The observed *Simulation Output* shows the dynamic behaviour of the organisational information system.
3. The *Soft Team* may involve *Decision Makers*.
4. The *Hard Team* may contain two collaborating design sub-teams: a *P Team* and an *IT Team*.
5. In the Soft Team and also in the Hard Team, there is a modeller familiar with the meta-methodology and having practice with SSM-MCM.
6. A new methodology *M23* is introduced. M23 is a methodology of controlling the collaboration of P Team and IT Team in the parallel and co-design of the set of P and IT simulation models.

We examine the following questions:
- What is the relationship between meta-methodology and the methodologies of the multi-methodology?
- How does the meta-methodology meet the requirements of the collaborative approach?

For the analysis, we compare the elements of the multi-methodology and the meta-methodology in the modified *collaborative modelling and simulation process*:
Meta-Methodology and M1:
M1 is covered by MM1, MM2 and MM3 phases of our meta-methodology. Here the resolution of the meta-methodology is higher: In the case of MM1 the goal setting is explicit, while in the case of M1 the goal setting is only implicit (the goal is to model and to simulate human activity systems in a way of building useful models). In MM2 the relevant data sources are selected carefully, but in a wider manner: not only about the "as-is" state (for example it may be decided to collect data about state "before-the-as-is", and also about the "to-be" state, etc.) and both formal and informal data may be gathered.
MM3 and its steps MCM1-MCM5 (in the part performed by the soft team) will help to eliminate the methodological gap between M1 and M2, between the soft (informal) and hard (formal) approaches, respectively.
Meta-Methodology and M2:
M2 is covered by SM3 of MM3 and by the part of MCM1-MCM5 performed by both sub-teams (P-team and IT-team) of the hard-team. MM3 will help to increase the efficiency of the co-design performed by the collaborative teams.
Meta-Methodology and M3:
M3 is covered by SM4 of MM3, but in our approach it should be a more compound step, it is about the creation of a set of models by hard-teams: P-models, IT-models, according to the scenarios derived from the system of goals.
Meta-Methodology and M4:
M4 is covered by MM4, with steps SM5 and SM6, but in the meta-methodology the simulation outputs are not only observed, but the results of the observation are to be presented to the decision makers and the question of implementation is also discussed.
Meta-Methodology and M23:
In the meta-methodology, M23 is supported by MCM1-MCM5 of MM3 fulfilling the requirements of the collaborative approach.

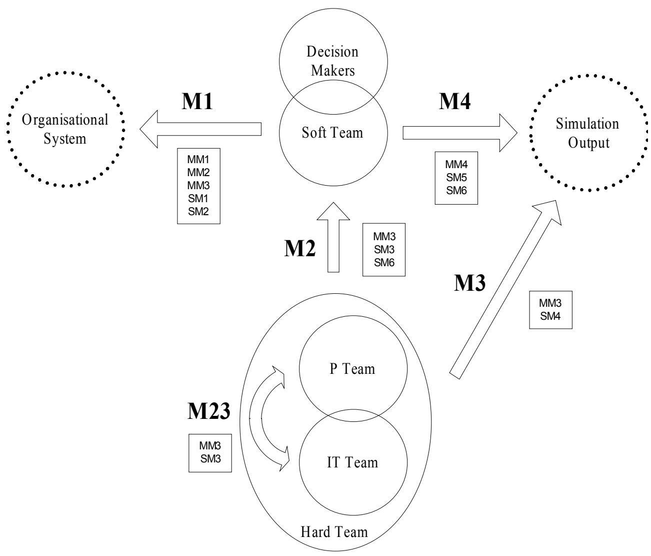

Figure 4. Collaborative Simulation Model Development Using the Meta-Methodology

In Figure 4. we show the methodologies of the multi-methodology and the meta-methodology elements realizing the function of the given methodology.

CONCLUSIONS

In this paper, we have given a detailed description of our previously outlined simulation meta-methodology, defining the full set of methods and the process of the simulation meta-methodology.

We have given an exact description of our hard six-step simulation methodology. We have defined the main output of the methodology at each step.

We have also defined the role of traditional SSM in the meta-methodology.

We have proposed a new approach, to use only TFA-EFA for preliminary modelling in the meta-methodology.

We have examined the relationship of hard and soft methods of the meta-methodology in the organisational world.

We have described the use of the simulation meta-methodology in a collaborative environment.

REFERENCES

Jackson, M.C., Keys, P. 1984 *Towards a System of Systems Methodologies* J. Opl. Res. Soc. Vol. 35, No. 6.

Jackson, M.C., 1991. *Systems Methodology for the Management Sciences* Plenum Press, New York, London

Checkland, P. 1985 *Achieving "Desirable ad Feasible" Change: An Application of Soft Systems Methodology* J. Opl. Res. Soc. Vol. 36, No. 9.

Checkland, P. 1989 *Soft systems methodology* In Rational Analysis for a Problematic World, Edited by J. Rosenhead, John Wiley & Sons Ltd

Checkland, P., Scholes, J., 1990. *Soft Systems Methodology in Action* JohnWiley & Sons Ltd., Chichester UK

Gregory, F. 1993. *Cause, Effect, Efficiency and Soft Systems Models* J. Opl. Res. Soc. Vol. 44, No. 4.

Koubarakis, M., Plexousakis, D. 1999 *Business process modelling and design – a formal model and methodology* BT Technol. J. Vol. 17, No. 4.

Sierhuis, M., Selvin, A.M. 1996. *Towards a Framework for Collaborative Modeling and* Simulation, Workshop on Strategies for Collaborative Modeling & Simulation, CSCW '96, Boston, MA

Sierhuis, M., Clancey, W.J. 2002. *Modeling and Simulating Work Practice: A Method for Work System De*sign IEEE Intelligent Systems, September/October 2002, Vol. 17, No. 5. pp.32-41.

Elassys Consulting Ltd. 2007 *Iminet and Imiflow Systems* http://www.elassys.hu

Lencse, G. 1999. *Applicability Criteria of the Statistical Synchronization Method* Proceedings of Communication Networks and Distributed Systems Conference (CNDS'99), (San Francisco, CA, USA, January 17-20.) SCS, 159-164

Lencse, G.: 2004. *Combination and Interworking of Traffic-Flow Analysis and Event-Driven Discrete Event Simulation* Proceedings of the 2004 European Simulation and Modelling Conference (ESM®'2004) (Paris, France, Oct. 25-27. 2004.) EUROSIS-ETI, 89-93.

Lencse, G. 2005. *Speeding up the Performance Analysis of Communication Systems* Proceedings of the 2005 European Simulation and Modelling Conference (ESM®'2005) (Porto, Portugal, Oct. 24-26.) EUROSIS-ETI, 329-333.

Lencse, G; Muka, L., 2006a *Convergence of the Key Algorithm of Traffic-Flow Analysis* Journal of Computing and Information Technology, Vol. 14, No 2, June 2006, 133-139.

Lencse, G., Muka, L. 2006b *Expanded Scope of Traffic-Flow Analysis: Entity Flow-Phase Analysis for Rapid Performance Evaluation of Enterprise Process Systems* Proceedings of the 2006 European Simulation and Modelling Conference (ESM'2006) (Toulouse, France, 2006. Oct. 23-25.) EUROSIS-ETI, 94-98.

Muka, L., Lencse, G., 2006. *Developing a Meta-Methodology Supporting the Application of Parallel Simulation* Proceedings of the 2006 European Simulation and Modelling Conference (ESM'2006) (Toulouse, France, 2006. Oct. 23-25.) EUROSIS-ETI, 117-121.

Pongor, Gy., 1992. *Statistical Synchronization: a Different Approach of Parallel Discrete Event Simulation* Proceedings of the 1992 European Simulation Symposium (ESS'92) (Nov. 5-8, 1992, The Blockhaus, Dresden, Germany.) SCS Europe, 125-129

BIOGRAPHIES

GÁBOR LENCSE received his M.Sc. in electrical engineering and computer systems from the Technical University of Budapest in 1994 and his Ph.D. in 2000. The area of his research is (parallel) discrete-event simulation methodology. He is interested in the acceleration of the simulation of communication systems. Since 1997, he works for the Széchenyi István University in Győr. He teaches computer networks and networking protocols. Now, he is an Associate Professor. He does R&D in the field of the simulation of communication systems for the Elassys Consulting Ltd since 1998.

He is a member of IEEE Hungary Section, IEEE Computer Society and IEEE Communications Society.

LÁSZLÓ MUKA graduated in electrical engineering at the Technical University of Lvov in 1976. He got his special engineering degree in digital electronics at the Technical University of Budapest in 1981, and became a university level doctor in architectures of CAD systems in 1987. Dr Muka finished an MBA at Brunel University of London in 1996.

Since 1996 he has been working in the area of simulation modelling of telecommunication systems, including human subsystems. He is a regular invited lecturer in the topics of application of computer simulation for performance analysis of telecommunication systems, at the Széchenyi István University of Győr.