COMBINATION AND INTERWORKING OF FOUR MODELLING METHODS FOR INFOCOMMUNICATIONS AND BUSINESS PROCESS SYSTEMS

Gábor Lencse
Department of Telecommunications
Széchenyi István University
Egyetem tér 1.
H-9026 Győr, Hungary
e-mail: lencse@sze.hu

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

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ABSTRACT

This paper describes how we can use four modelling methods together. We model Information and Communication Technology (ICT) systems and Business Process (BP) systems. The aim of the modelling is to experiment with the models, that is, simulation. Two of the methods are the detailed modelling of the ICT and of the BP systems, as we usually do that for discrete event simulation. The other two methods are those that enable us to make rapid performance analysis of these systems, namely Traffic-Flow Analysis (TFA) for ICT systems and Entity Flow-phase Analysis (EFA) for BP systems. The solutions for the combination and interworking of these methods are described.

INTRODUCTION

Mixed Simulation Projects

Simulation projects aimed at supporting the design of Information and Communication Technology (ICT) systems and Business Process (BP) systems in an organisation are traditionally independent, separate projects, in spite of the fact that these systems may have significant influence on each other. Common analysis of these systems may have advantages, but in this case we need to have methods appropriate for both types of systems. That is, we need models of the two types of systems that can interact with each other, because the two types of systems interact with each other in the real world, too.

Detailed Modelling of ICT Systems: DES-IT

As for the detailed modelling of ICT systems, we usually model some servers (database, web, etc.) and the communication networks. We model the networks as a graph of nodes and lines. The load of the systems we describe by applications that use some services. They cause load for the servers by their requests, and for the network by communication: sending and receiving packets to/from the servers (or sometimes to/from each other). Discrete event simulation can be used to make experiments with this type of models. We use the abbreviation DES-IT, to distinguish it from the simulation model of the BP systems.

There are well known simulators for ICT systems, especially for communication networks, such as: OPNET Modeler, BONeS or ImiNet (Elassys 2007).

Detailed Modelling of BP Systems: DES-P

As for BP systems, we use the definitions we have given in (Lencse and Muka 2006):

"Business processes are related to enterprises and they define the way in which the goals of the enterprise are achieved.

A Business Process is a set of Enterprise Activities linked together to form a process with one or more kinds of input to produce outputs."

We model a BP system by a graph built up from activities (as nodes) and links (as edges) between them. The load is modelled by entity generators, which generate entities of different types according to given probability distributions. The entities travel through the network according to the routing decisions of the activities. The activities use resources of given types with limited capacities. The activities forward the entities after some processing delay that depends on the type of the entity, the type of the activity and the availability of the limited resources.

The simulation model we use for the detailed discrete-event simulation of a BP system is named DES-P.

Simulators for BP systems include SIMPROCESS, ARIS and ImiFlow (Elassys 2007).

Similarities & Differences Between DES-IT and DES-P

Hopefully, the reader has already noticed the formal similarity between DES-IT and DES-P. In both cases we have a graph, and some objects are travelling through the graph. However, the interpretation of the model elements is very different, that is why the simulators of the two types of systems are quite different.

Rapid Modelling of ICT Systems: TFA

The Traffic-Flow Analysis (TFA) (Lencse 2001) is a simulation-like method for the fast performance analysis of communication systems. TFA uses statistics to model the networking load of applications.

In the first part, the method distributes the traffic (the statistics) in the network, using routing rules and routing units.

In the second part, the influences of the finite line and switching-node capacities are calculated.

The important features of TFA:

- The results are approximate but the absence or the place of bottlenecks is shown by the method.
- The execution time of TFA is expected to be significantly less than the execution time of the detailed simulation of the system.
- TFA describes the steady state behaviour of the network.

As TFA is a less well-known method, it has only one partial implementation, which is a part of the aforementioned ImiNet network expert system.

Rapid Modelling of BP Systems: EFA

The Entity Flow-phase Analysis (Lencse and Muka 2006) has been derived from TFA. This derivation is based on the formal similarity of the DES-IT and DES-P models. EFA uses the same two phase method as TFA, only the interpretation of the model elements is different. The statistics represent entities (not messages) and the interpretation of the routing is also different. While the packets of a network usually do not multiply, the entities may fork (and the descendants must meet somewhere) or split (and the descendants live their own life separately); see more details in the aforementioned paper.

An implementation of EFA is planned as an extension for the ImiFlow system.

Our Goal is to Use the Four Methods Together

Why do we believe, that the combination of the four methods may be beneficial?

Combining ICT and BP Models
As we have already mentioned, the ICT and BP systems are not independent, but interact with each other. If we model and simulate them separately, we usually consider the effects of the other one to the modelled one only as parameters or random variables. Modelling the two systems together (and their interactions) may give a richer picture of the whole system containing ICT and BP parts.

Combining the Detailed and the Rapid Models
As a motivating example, let us consider an ICT system: a high-availability server (realised by a cluster of multiple servers), its immediate network neighbourhood and the whole network of the company that uses the server. To study the behaviour of the high-availability server, we need the detailed simulation of the high-availability server and its immediate network neighbourhood, but the detailed simulation of the whole network of the company (consisting of hundreds of switches and thousands of computers) would require so much computing power (and perhaps even memory) that we can not afford. However, the omission of the network and direct connection of all the client applications to the high-availability server would oversimplify the situation. The application of DES-IT for the high-availability server and its immediate network neighbourhood and the application of TFA for the rest part of the network may be beneficial.

In the rest of this paper we examine how the four modelling methods can be used together for more precise or for more computation efficient performance analysis of a system containing both ICT and BP parts.

COMBINATION OF THE FOUR MODELLING METHODS

To be able to use two (or more) methods together, we must be able to teach them 'how to speak each others language'. Figure 1. shows four possible interactions between the neighbouring methods. These are:

1. DES-IT – TFA
2. DES-P – EFA
3. DES-IT – DES-P
4. TFA – EFA

The first one has already been discussed in details in (Lencse 2004), now we just give a short summary.

Combination of DES-IT and TFA

We have an ICT system. One segment of the system is modelled for DES and the other segment is modelled for TFA. Of course, traffic exists between the two segments. To enable the two models to speak each others language, we need bidirectional conversion between their different traffic representations – messages and statistics – on the boundary of the two segments. When the traffic travels from the DES segment to the TFA segment, the representation mode is changed from messages to statistics. It means that we need to collect the appropriate statistical characteristics of the message flow, and perhaps it is necessary to transform the results to the kind of statistics that are used in the TFA segment. In the opposite direction, where the traffic travels from the TFA segment to the DES segment, messages should be generated on the basis of the statistics (called *traffic model* in the original TFA terminology) of the TFA segment. The characteristics of the message flow such as the distribution of the message length, inter-arrival time, the source and destination of the packets are representing the same information that is coded in the statistics travelling from the TFA segment to the DES segment.

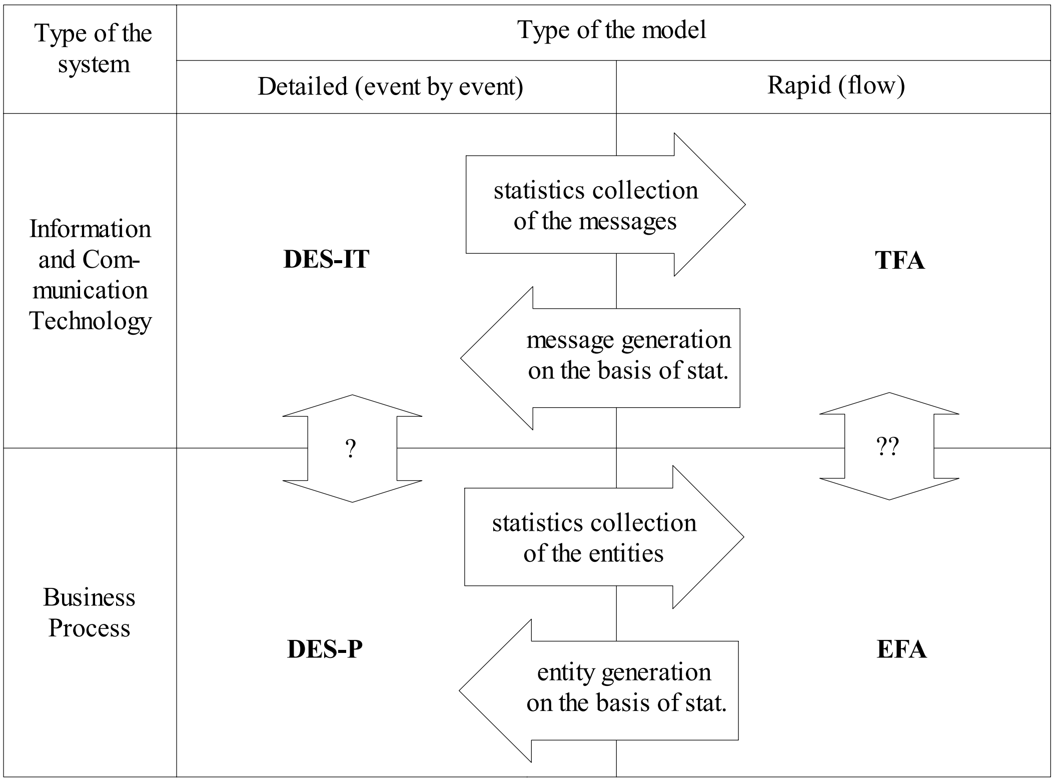

Figure 1. - Relationships between modelling approaches – we have two open questions

Combination of DES-P and EFA

Using our previous observation of the formal similarity of DES-IT and DES-P, plus the fact that EFA is nothing else than the application of the TFA principles for a BP system, we can reuse our previous results for this case. We can say the same about the combination of DES-P and EFA that we have just said about the combination of DES-IT and TFA, we must only replace the words “messages” and “traffic model” by the words “entities” and “entity-load model”, respectively.

Combination of DES-IT and DES-P

Despite the formal similarity of DES-IT and DES-P, the combination of the two models is not trivial at all. The formal replacement of messages by entities and vice versa would result in a nonsense system! Their semantics are very much different!

Now let us identify, what kind of interactions are possible between the ICT and the BP systems. We have found the following three possible cases:

1. An activity of the BP system uses the ICT system.
2. An activity of the BP system sends information to another activity of the BP system using the ICT system.
3. The ICT system acts as an initiator towards the BP system.

Let us examine the points above one by one in detail.

1. An Activity of the BP System Uses the ICT System

As an example, let us consider a help desk system, where a consultant (part of the BP system) would like to know a client's e-mail address and makes a database query. (See Figure 2.) This query causes a load for the ICT system (for both the database server and the communication network between the consultant's computer and the server). The response time depends on the type of the given query and the other load of the ICT system, that is the other traffic that uses the same network and the other queries sent to the same database server.

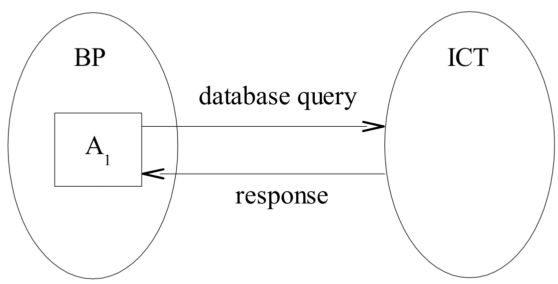

Figure 2. Database request and response

By modelling the BP and the ICT systems separately, both models would be less accurate. As for the BP system, we could model the response time with a random variable. As for the ICT system, we could model the different database queries by a packet source, that sends requests to the database server through the network according to a given time distribution (e.g. according to a Poissonian process).

The combined modelling of the BP and the ICT systems can be much more accurate.

2. Two Activities in the BP System Use the ICT System for Communication

To continue the previous example, let the consultant send an e-mail to the client. Similarly to the previous case, the BP systems causes load to the ICT system. Similar things can be said about the situation as we said before, but there is a difference: there is communication between the two activities of the BP system. This communication is also modelled within the BP system even when the two systems are simulated separately.

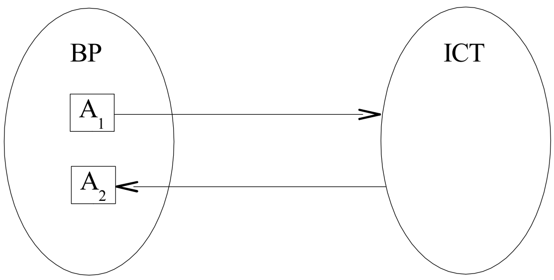

Figure 3. Communication through the ICT system

3. The ICT System Acts as an Initiator Towards the BP System

Let us begin with two examples. When a car driver uses GPS navigation, he regularly gets information from the navigation software (e.g. by voice messages or by checking the screen of his PDA). When something crucial happens, e.g. the cooling water of the car boils, the driver gets a warning message.

Figure 4. The ICT system initiates towards the BP system

In both examples, the ICT system produces entities (carrying information) that are processed by an activity (performed by the driver). As we have seen it before, the quality of our model of the BP system was improved by connecting it to the ICT model.

We have not found any other cases that are significantly different from the three cases above. All other interactions can be described by their combination. Let us see examples for the composition. If the above mentioned consultant mistypes the e-mail address of the client, he will probably get an error message from the outgoing SMTP server of his company. We found that the generation of this error message is similar to case number one: if the e-mail address is invalid, the generation of the error message will surely happen, and its time depends on the load of the mail handling subsystem, like in the case of the database query mentioned before. However, there can be a different way of receiving an error message. The client may further process, e.g. redirect his mails to a different address. If the error message is produced because of the client's improper mail settings, we might model the situation by case three, where the ICT system acted as an initiator towards the BP system. As a third example, if the consultant asks for a read confirmation when sending the e-mail to the client, the sending of the read confirmation we see as another action of the client (as an activity), and as it is an e-mail sending, it can be categorized as case two.

Combination of TFA and EFA

The reader may ask: Why do we deal with this question at all? At an intersection of two roads three pedestrian crossings are enough. Really? See figure 5. Probably all of us would like to choose the shortest path. That's why we must cope with this problem of conversion between TFA and EFA. However we can use the detour for the solution. First, we interpret the entity statistics of EFA with the help of the DES-P model. Second, we examine the effect of the entities to the DES-IT model. Third, we collect statistics of the messages for the TFA model. To explore the effect of the TFA statistics to the EFA part, we follow the same detour in the opposite direction. However, we need to do this only once per message/entity types in the phase of model building, that is, before the execution of the simulation. We make rules (or tables) for the conversion, and we can use them during the simulation.

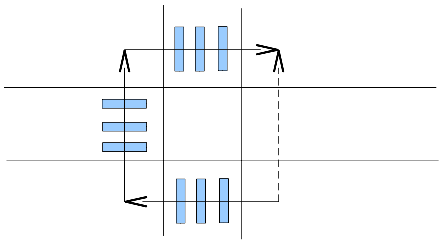

Figure 5. Are three cross-walks enough?

THE PROBLEM OF INTERWORKING

So far, we were concerned only with the conversion between the different traffic representations (e.g. between DES-IT and TFA) or interpretations (e.g. between DES-IT and DES-P) of the models. It was crucial to bridge the gap between them, otherwise we would have had no chance to make them work together. Is there any other problem to solve? Yes! There is the problem of model time (also called virtual time). This problem requires three different handling methods depending on which two models we want to cooperate.

Interworking of DES-IT and DES-P

If we are lucky enough and use the same modelling framework for the ICT and BP parts of the system and we also execute the model as a single process, then the event-driven discrete-event simulation kernel handles the events correctly: the causality is ensured between the two parts of the model. (This is the situation in the case of ImiNet and ImiFlow.) If we use two different frameworks for the ICT and BP parts of the system, we must equip them with proper input and output interfaces that provide the data for and receive the data from the other model. Plus we have to deal with time synchronisation. We can use one of the well known synchronisation methods for parallel discrete-event simulation (Fujimoto 1990), namely conservative or optimistic. If the applicability criteria (Lencse 1999) are met, we may consider SSM-T, the time-driven version of the Statistical Synchronisation Method (Lencse 1998).

Interworking of DES-IT and TFA

Here the problem arises from the different usage of virtual time of the two methods. Virtual time elapses in the DES-IT, but TFA describes the steady state behaviour of the system. This problem was explored in full depth and two different solutions were proposed in (Lencse 2004). These solutions can be used for the interworking of DES-P and EFA, too.

Interworking of TFA and EFA

The virtual time handling of the two methods is the same, we only have to take care of the good interweaving of the traffic of the models, that is their own traffic and the traffic coming from (or caused by) the other part. For more details see (Lencse 2001), (Lencse 2004) and (Lencse and Muka 2006).

Interworking of more than two types of models

The interworking of more than two types of models seems to be possible and can be the direction of future research. The parallel execution of multiple models by multiple computers may result in a good speed-up, if we consider the results in (Lencse 2005), where only two of the methods (DES-IT and TFA) were used together.

CONCLUSIONS

We have briefly introduced four methods (DES-IT, DES-P, TFA and EFA) for the performance analysis of ICT or BP systems.

We have shown the way for their combination: how they can be combined in spite of their different traffic representation or interpretation.

We have also given the solutions to the problem of their interworking, ie. the synchronisation of their virtual time or the reconsiliation of their different usage of virtual time.

We conclude that the combination and interworking of the four methods may result in more accurate modelling, better simulation results and may also give a good chance to efficient parallel execution of the simulation of a system containing ICT and BP parts.

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BIOGRAPHIES

GÁBOR LENCSE received his M.Sc. in electrical engineering and computer systems at 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 info-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 is a founding member of the Multidisciplinary Doctoral School of Engineering, Modelling and Development of Infrastructural Systems at the Széchenyi István University. He does R&D in the field of the simulation of communication systems for the Elassys Consulting Ltd. since 1998. Dr Lencse works part time at the Budapest University of Technology and Economics (the former Technical University of Budapest) since 2005. There he teaches computer architectures.

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 Multidisciplinary Doctoral School of Engineering, Modelling and Development of Infrastructural Systems at the Széchenyi István University of Győr.