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PROBLEM SOLVING, MODEL SOLVING, OR WHAT?

Ray J Paul

Brunel University
Department of Information Systems and Computing
West London, UK

Jasna Kuljis

Brunel University
People and Interactivity Research Centre
Dept. of Information Systems and Computing
West London, UK

ABSTRACT

Simulation Modeling may have moved on from its early days as decision aiding and problem investigation. Large models of complex partially understood problems are being commissioned from model builders to enable investigations of the problem the model addresses. This paper raises the issues that need to be considered and thought about such situations.

1 SIMULATION MODELING IN USE

Even before setting out the objectives of the CASM (Centre for Applied Simulation Modelling) research group in 1990 and 1992 (Balmer and Paul, 1990, Paul 1992), members of the group had been interested in the process of using simulation modeling in decision aiding. Of the 30 plus papers presented at WSC since 1992, many have covered this interest, not the least being the more recent papers by Kuljis and Paul (2000), by Paul et al (2003), by Paul et al (2005) and the panel by Paul et al (2005a).

The 2005 paper in particular addressed the issue of model solving being the real outcome of much simulation modeling endeavor as opposed to what one might expect it to be, that is problem solving. The evidence seems indisputable. For example, in an examination of four simulation journals for the year 2004, the following results shown in Table 1 were discovered.

Table 1: Evidence of Problem Solving in Published Papers (Paul et al, 2005)

Journal	No stakeholder owner	Stakeholder owner	Some solution?	Implemented?	Total
TOMACS	15 (100%)	0 (0%)	0 (0%)	0 (0%)	15
SIM	45 (88.2%)	6 (11.8%)	5 (83.3%)	0 (0%)	51
S&G	13 (92.9%)	1 (7.1%)	1 (100%)	0 (0%)	14
SMPT	25 (89.3%)	3 (10.7%)	2 (66.7%)	0 (0%)	28
Total	98 (90.7%)	10 (9.3%)	8 (80%)	0 (0%)	108

Legend:
TOMACS - ACM Transactions on Modeling and Computer Simulation
SIM - Simulation
S&G - Simulation and Gaming
SMPT - Simulation Modelling Practice and Theory

Even if matters have improved since 2004, a cursory examination of the literature suggests there has been no major step change, and that papers that have some evidence of some problem stakeholder involvement, or that have some problem solution reported on are at about the same level of 10% of all papers published, and evidence of some implementation based on the simulation study is almost non-existent.

So the conclusion arrived at in 2005 was that there was too much emphasis in the community on model solving, which can be detrimental to both the study concerned, and to the future use of simulation modeling in decision aiding. Subsequent investigation suggests that there are other considerations that should be included in this big picture view of using simulation modeling, and in this paper we introduce one such consideration in section 4. But first, in sections 2 and 3 we explain two approaches used in decision aiding using simulation modeling. These two approaches will be used to show how modeling with the approach described in section 4 provides many opportunities for the analyst to hurt his/her head when trying to help with these problems, as will be discussed in sections 5 and 6.

2 DISPOSABLE MODELING

As previously described in Paul et al (2003) and Paul et al (2005), when the problem to be studied is to determine what the real problem actually is, the modeling approach would be to use the standard modeling cycle, but assuming it is in error at all times, so that the cycle keeps returning to the question of what the problem really is. So the modeling process is a method of structured debate in order to tease out the problem itself. Table 2 shows the revised modeling approach. Since the problem is being continuously updated, it would be safer to build a new model at each change of understanding, and so the previous model is discarded. Hence the term 'disposable modeling'.

Table 2. Disposable Modeling When the Problem is Unknown

Step	A Common Approach	Paul, Eldabi and Kuljis (2003)
1	Formulate problem and Plan the study	Problems have owners. They do not understand what the problem is. If they did, they would make decisions. Hence problem formulation is wrong.
2	Collect data and define a model.	What data? How relevant and accurate is it. The model is wrong.
3	Conceptual model valid? Go to 4, else return to 2.	The conceptual model cannot be valid (this can rarely be even attempted).
4	Construct a computer program and verify.	Computer programs cannot be verified. The computer program is wrong.
5	Make pilot runs.	The pilot runs give wrong outputs.
6	Programmed model valid? Go to 7, else return to 2.	The programmed model cannot be valid. The programmed model is wrong.
7	Design experiments.	The experiments are wrong.
8	Make production runs.	The production runs produce wrong outputs.
9	Analyze output data.	The analysis is wrong.
10	Document, present, and use results.	The results are wrong.

This table presents practically motivated observations on the 10 steps of the Modeling Process (Paul, Eldabi and Kuljis, 2003). Simulation is usually resorted to because the problem is not well understood. We might therefore assume that a practitioner's knowledge of the problem is wrong. The 10 steps become a debating device between the practitioner and the problem owners, constantly backtracking, especially to step 1, with the aim to get an ever closer understanding or appreciation of what the problem *really* is. Eventually the problem owners get to a point where they think they understand the problem and then, ignoring the simulation (and the practitioner!), they go off and make decisions and get on with their lives. This by definition ends the simulation process.

3 SOFTWARE ENGINEERING

If the simulation model is being used to emulate some existing or proposed system (for example, a new class of warship), then the model needs to reflect as accurately as possible, and at the right level of fidelity, the actual system being modeled (similar therefore to children's models, a scaled down version of the original, but in this case a numerical model rather than plastic or balsa wood). In this case it may be appropriate to build the model using a classical software engineering approach such as that advocated for some time by Nance (1994). As long as the system being modeled is well understood, then such a static approach may well be suitable and the model used to ask many questions about the behavior of the real system before the latter is built at great cost.

Figure 1 shows the two approaches to modeling discussed so far. They represent, to some extent, two extreme positions. When the problem is well understood, then it is possible to build a model using software engineering techniques. When the problem is unknown, and the modeling is being used to find out what the problem actually is, then the model should at all times represent the current view of the problem at that time. Hence the model should be disposed of and a new model created when the change in understanding is great enough.

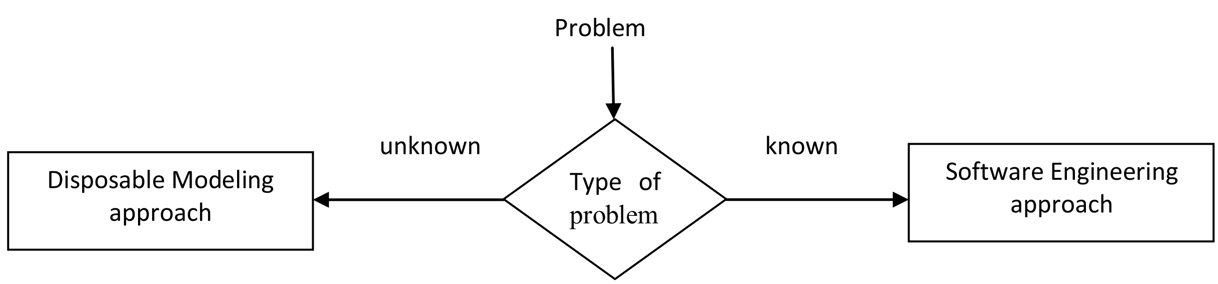

Figure 1: The two simulation modeling approaches

4 INVESTIGATIVE MODELING

Since 2005 we have continued to look into the use of simulation modeling in practice and have discussed with a variety of simulation model suppliers whether they are supplying software to discover the underlying situation, or to represent a well understood problem. The majority of answers were negative about either choice! So what were they doing?

It appears that a lot of simulation modeling consultancy is about the building of a model that can be used to investigate a large problem area which has a high degree of uncertainty as to how all the variables in the problem or system interact. Examples might be a country's economy, or global warming. The model is intended to be used by the customer to investigate a variety of what-if questions about the way the real world works. So, in terms of our approaches to modeling discussed in this paper, this investigative modeling approach would appear to lie somewhere in between the first two approaches (see Figure 2).

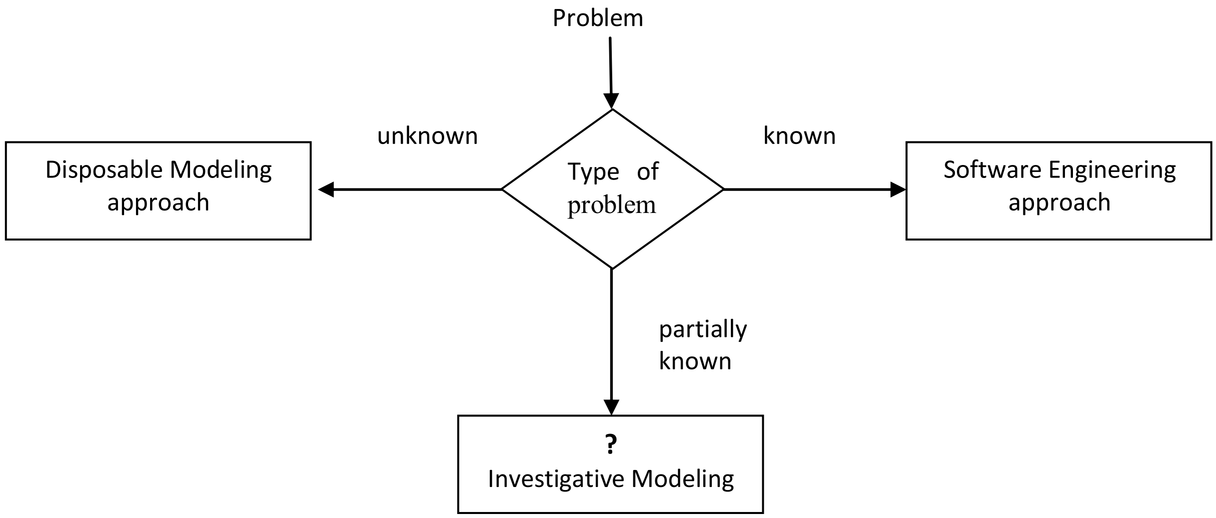

Figure 2: The three simulation modeling approaches

5 COMPARING THE THREE APPROACHES

So, if the problem is known, a model built around this knowledge using software engineering principles can be built and presumably it can then answer the questions it is designed to deal with. Since everything is known, the model if properly verified validated and assured will probably be useful in the hands of intelligent trained analysts.

If the problem is unknown, then quick and dirty model building can enable a fast interactive route to help the customer to become more aware of what the problem is, each model being disposed of after each iteration. The expectation is that when the customer appreciates the problem well enough to their satisfaction, they quit the debating process and go off and make decisions (which are after all their forte).

Investigative modeling appears to lie between these two extremes, with each aspect of the approach used being in contradiction with how the other two situations are dealt with. In other words

1. The problem is unknown in its entirety, and yet there is no iterating around disposable models to uncover what the problem is.
2. Software Engineering might be used to build the model, even though the problem is not static.

However, how these investigative models are actually built is not published very frequently, so it is difficult to comment. But there are dangers behind the investigative approach in general which we shall now look at.

6 THINGS THAT CAN GO WRONG

Many years ago the Financial Times had a headline for one of its articles that said something like “Treasury Model Wrong”. The ‘Treasury Model’ being referred to was a model of the U.K. economy. We do not know enough economics to build an accurate economic model for any country, so a Treasury Model cannot be right. The Financial Times headline was a statement of the obvious.

Even when we think we know what we are modeling there are many problems: we do not have the software skills to know if the software is doing the right thing; we cannot be certain that the logic of the problem is faithfully represented in the model; we cannot be sure that the assumptions built into the model, the uses it was designed to be put to and not put to, will be adhered to by future users etc. And then with the passage of time, and probably with some model updates, corrections, and possible changes of logic, we cannot be sure of the way the model works at all. For example, some years ago there was a direct fire battle model, an aggregation of more complex models that therefore was not even a true simulation, and which had been built and developed over the course of 10 years by a fair number of very bright scientists. One of the authors (Paul) was a member of the team that were given a contract to go through the code and report back on how it worked. The model needed to be calibrated before serious use, and in particular there was a 'sensitivity' factor which needed to be pre-determined and input to the model. A lot of data for a new study would be spent on determining this sensitivity factor that would then be suitable for the study to be undertaken with the rest of the available data. Analysis of the code showed that the sensitivity factor, which was read into the model run, was stored but never applied. It had been disconnected some years earlier!

Apart from the above problems, investigative modeling has uncertainties about the problem which affect model structuring. How do you go about dealing with this? Presumably not by disposable modeling. Are there any mechanisms, processes, procedures being used to tease out the unknown to enable the model to be enhanced? Or is this the customers' problem?

7 CONCLUSIONS

Simulation Modeling has matured, and now research centers, and private and government research agencies, are commissioning the development of quite complex models of complex partially understood problem areas. The commissioners of such models expect to get a working model to carry out their investigations. The developers of such models expect to deliver what was asked for.

But who is looking after the veracity of the model, checking on the inbuilt unknown behaviors of the problem, maintaining records of what has been uncovered about the problem domain as experiments are carried out in order to update the model? These matters may be well in hand, but there is little public evidence of that. Such evidence as there is should be put in the public domain to benefit all such research, and if the evidence is weak, then a program of research into these issues needs to be urgently funded.

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AUTHOR BIOGRAPHIES

JASNA KULJIS is a Professor and Head of the Department of Information Systems and Computing at Brunel University. She gained her Dipl. Ing. degree in Theoretical Mathematics from the University of Zagreb, Croatia. She gained her M.S. in Information Science from the University of Pittsburgh, USA, and a Ph.D. in Information Systems from the London School of Economics, University of London. Her current research is in Human Computer Interfaces. She is mostly interested in the design of graphical user interfaces and in the development of new paradigms that would further enhance the usability of interactive computer systems. She is Director of the People and Interactivity Research Centre at Brunel University. Dr. Kuljis' email address is <jasna.kuljis@brunel.ac.uk>.

RAY J. PAUL is an Emeritus Professor of Simulation Modelling, Director of the Centre for Applied Simulation Modelling, creator of the Centre for Living Information Systems Thinking, all at Brunel University, UK. He received a B.Sc. in Mathematics, and an M.Sc. and a Ph.D. in Operational Research from Hull University. He has published widely, in books, journals and conference papers, many in the area of simulation modeling and software development. He has acted as a consultant for a variety of United Kingdom government departments, software companies, and commercial companies in the tobacco and oil industries. He is the editor of the *European Journal of Information Systems*. His research interests are in methods of automating the process of modeling, and the general applicability of such methods and their extensions to the wider arena of information systems. He is currently working on wider aspects of simulation, in particular in Web-Based Simulation and the new Grab-and-Glue modeling technique. His email address is <ray.paul@brunel.ac.uk>. Ray has Parkinson's Disease, but insists on working part-time because he enjoys it. He is author of the soon-to-be bestselling book *Living with Parkinson's Disease: Shake Rattle and Roll.* See <www.rayjpaul.com>.