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WHAT USE IS MODEL REUSE: IS THERE A CROOK AT THE END OF THE RAINBOW?

Ray J. Paul
Simon J.E. Taylor

Centre for Applied Simulation Modelling
Department of Information Systems and Computing
Brunel University
Uxbridge, Middx UB8 3PH, U.K.

ABSTRACT

The emergence of new technologies in simulation modeling such as the World Wide Web has fostered debate on the reuse of models. In this paper we present a case for model reuse and the pot of gold that it promises. We then discuss model reuse from the viewpoint of simulation modelers who use COTS simulation packages and suggest that model reuse may in fact cost more than developing new models as candidates for reuse as trust must be established through thorough testing. An alternative to this is put forward that suggests that a Grab-and-Glue, Run, Reject, Reply (G^2R^3) approach is a more appropriate use of model reuse as it emphasizes the intellectual process of problem understanding rather than model correctness as an means to itself.

1 INTRODUCTION

Since the appearance of web-based simulation at the Winter Simulation Conference in 1996, the theme of model reuse and its methodological and technological support has attracted much discussion and debate in the modeling and simulation community. Several interesting contributions have been made in this area. Page, et al. (2000) present a stimulating discussion based on a panel convened at WEBSIM 98 that discussed the web "revolution" or "evolution" (Page, et al. 1998). Following on from this, Miller et al. (2001) reported the outcomes of the WEBSIM 2000 Panel concerning the opportunities and problems of the commercialization of web-based simulation (Miller, et al. 2000). Both have highlighted that technology is often an enabler (and barrier) of model reuse. A similar comment can be made on distributed simulation (especially the High Level Architecture). Recently, a debate on model reuse was held at the two-day UK Operational Research Society Simulation Workshop (Eldabi, et al. 2002) This debate has stimulated several outcomes on the theme of model reuse.

This paper attempts to foster further discussion on this theme by challenging commonly held views on model reuse to determine if this is a realistically achievable goal. If, as it will be argued, it is not, then is there really a crook at the end of the rainbow or a pot of gold that we all seek?

The paper is structured as follows. In section 2 we put forward a case for model reuse. Section 3 considers this from the viewpoint of simulation modelers who use COTS simulation packages and suggests that model reuse may in fact be more costly than developing new models. Section 4 introduces the G^2R^3 approach (Grab-and-Glue, Run, Reject, Reply) and suggests that this may be a better candidate for model reuse as it emphasizes the intellectual process of problem understanding rather than model correctness as a means to itself. Finally Section 5 concludes the paper.

2 A CASE FOR MODEL REUSE

Let us consider the justification for the reuse of models from the viewpoint of a traditional simulation modeling process as shown in figure 1. A real world problem exists. The problem is formulated as a conceptual model, an abstraction of the problem system. The conceptual model is then transformed into a computer model using either bespoke code, some form of commercial-off-the-shelf (COTS) modeling package (Arena, Witness, Simul8, etc.), or a combination of both. The computer model is verified to determine if it correctly functions and then validated to determine if it appropriately represents the real world. The model is then used as an operational model for experimentation to produce results that can be analyzed to produce conclusions. As has been pointed out by many authors, there are often many iterations of this process and the sequence of steps often varies as the understanding of the problem being studied develops. Additionally, there is usually an implicit assumption that the product of this process is a set of results, typically numerical, that leads decision makers to some conclusions and implementation of decisions.

In terms of the above process, it may be that the development of a conceptual model could be the most diffi-

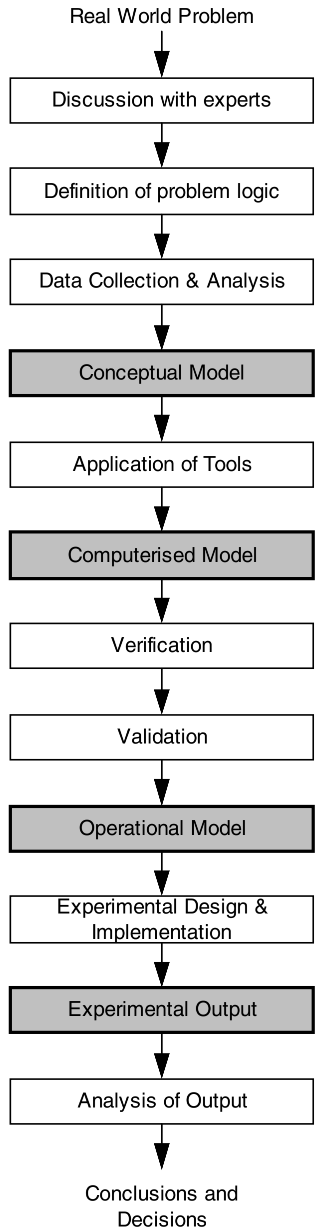

Figure 1: A Simulation Modelling Process

cult part. Real world problems are owned by interest groups (stakeholders). Problems are influenced by these stakeholder owners, some of which may be in conflict. For complex problems, problem formulation may be an extremely difficult task. A conceptual model is essentially the representation of a problem that has been agreed by all stakeholders. A poorly formulated problem and a poorly defined conceptual model will doom a simulation project to failure. To avoid this, the modeler should be prepared to constantly undertake reformulation and redefinition to achieve a common understanding of stakeholders views to best represent the problem.

The creation of a computer model from this conceptual model should be accomplished with relative ease. Large models may involve large time and cost overheads incurred by the iterative implementation and verification of the model. This is further complicated by the observation that the real world is not static and, irrespective of the best efforts of the modeler, it will change. Any time spent in developing and verifying the computer model is time that the real world will distance itself from the conceptual model that the computer model spend changing. Attempts to minimize this can be made by continued interaction with stakeholder groups. However, no matter how vital this is to the successful completion of the simulation task, it is an overhead and will prolong the process. It seems that the best approach to avoiding these problems is to use methods that simplify this implementation process. The reuse of previously developed models, models that already have had time invested in them, seems to be a promising candidate for the quick development of computerized models. The reduced costs that might come from model reuse might be considered by some as a pot of gold at the end of the rainbow!

In the next section, we approach model reuse from the viewpoint of modelers who use COTS simulation packages and argue that with traditional approaches to simulation modeling there is no pot of gold at the end of the rainbow but a crook waiting for the unwary.

3 WHAT USE IS REUSE?

To continue our discussion of model reuse consider the development of a computerized model using a COTS simulation package. Each package typically comes with a set of predefined components that represent entry/exit points, queues, workstations, resources and entities. New models are built by combining these to form an appropriate representation of the conceptual model. Examples include the identification of a bottleneck in a production line, what call handling strategy to use in a call center, or the impact of different triage policies in an accident and emergency ward. In some cases, models can be built from more complex components that are models that have been previously developed elsewhere, i.e. these models are reused. Experienced modelers have access to models that they have previously built and it might be possible for these models, or parts of models used to analyze analogous problems and systems to be adapted for use in different contexts. Similar arguments can be made for modelers working in a modeling team who have access to a shared model library, or for those COTS modeling packages that have libraries of modeling components.

For example, take the case of an owner of a factory who was unsure how to increase production. The factory owner takes on the services of a modeler to help develop a strategy to accomplish this. The modeler and the factory owner work together to develop a conceptual model. To implement this as a computerized model, the modeler has several apparent opportunities to save time on building the model by model reuse. These are

- **reuse of basic modeling components**. The modeler reuses the basic modeling components (workstations, resources, etc.) that come with the COTS modeling package.
- **reuse of subsystem models**. The modeler has models of various "generic" factory parts that he or she has previously developed or has access to though a model library (a conveyor subsystem is often a good example of this) that can be adapted and used with a new model representing the factory. Alternatively, the factory owner might have models of factory parts that were previously developed and makes these available to the modeler.
- **reuse of a similar model**. The modeler has previously developed a model that has similar features to the factory being studied. The model is adapted appropriately.

Do these actually save time? The first of these, "reuse of basic modeling components" is performed by the modeler selecting and using the modeling component. Experienced modelers will know that this is not entirely the full story. Take for example a workstation component. The developers of this component have made some assumptions about how workstations work. A modeler using this workstation in a model will have to test the workstation to understand how this actually works in the COTS modeling package as there is no standard cross-package behavior. When the modeler uses the workstation component, if it cannot appropriately model a particular machine, the modeler can take advantage of programming facilities or links to other programs (such as a spreadsheet) that most COTS packages make available. The implications of this is that models built this way come with "baggage", i.e. programmed behavior and/or supporting components that are required for the model to be simulated. This is made worse by "baggage" being extremely dependent on the version of the package, the platform being used, and even the way in which the operating system has been configured. The conclusion to this "reuse of basic modeling components" is that they are reused but only after testing has been performed and modifications have been made or added. The basic component often evolves significantly beyond its original form.

In the second of our opportunities for reuse, "reuse of subsystem models," the modeler identifies part of the factory that can be quickly modeled by reusing a previously developed subsystem component that comes from the modeler's own library or from the library of the modeling package he or she is using. Either way, the subsystem model has to be tested to determine if it correctly models the subsystem and then modified appropriately. If this complex component has "baggage", then these also have to be checked and understood. The implication of this is that unless a subsystem component is quite simple, a modeler will have to spend a great deal of time understanding how the component works. Additionally, one must ask what is the likelihood that the subsystem component will conveniently model the equivalent factory subsystem? The conclusion to this "reuse of subsystem models" is that for most cases the reuse of a subsystem model could be more costly than developing it from scratch.

Similar arguments can be made about "reuse of a similar model" where the thorough testing of the model will only take longer than testing a subsystem component. It is possible to see a similar model (with appropriate modifications) being reused as the system it represents evolves. However, it is ever likely that a model will be capable of being used to model another similar system. For example, production lines appear similar in that they tend to be a linear series of buffers and processing stations. Will two production lines really be that similar when studied in detail? Would a modeler be better off starting afresh rather than spending time attempting to establish how a similar model works and what modifications need to be made?

In summary to this section, we ask the question "What use is model reuse?" In the world of COTS simulation packages it is difficult to see practically how one can trust a model without detailed verification that may be more costly than developing the model from the start. It appears that a crook has stolen the pot of gold.

4 IS THERE REALLY A POT OF GOLD?

In the previous section we have essentially argued that model reuse is dependent on trust. If a modeler cannot trust a model then surely they cannot reuse it. It seems to follow that for a modeler to reuse a model, then the modeler must build trust, a process that might take more time than building the model from the start. Are we missing the point?

Simulation modeling is a decision aiding technique. Discrete event simulation modeling is a quantitative technique. Experimentation with operational models produces numerical results than can be used to indicate that one decision is better than another. However, numbers cannot represent all possible factors at play in the system being studied (the relationships between stakeholders, for example). One must remember that the process of simulation modeling is not designed to find the answer or answers. It is there to help decision makers make decisions, or to help decision makers gain an *understanding* of their problem. It may be that the numerical output of the simulation model in itself be of no intrinsic value. Learning about the processes of the interactions that go on within a complex environment, the relationships between the variables, is probably the dominating reason for using simulation modeling.

With the World Wide Web we are faced with the potential to change the way in which we model. There are many applications that are used on the Web that loosely foster a "suck it and see" approach. Browsing and adventure games encourage the participant to try out alternatives with rapid feedback, avoiding the need to analyze a problem with a view to deriving the result. In terms of simulation modeling, we might advocate development tools that allow for fast model building and quick and easy experimentation, tools that allow simulation models to be used for problem understanding (Paul and Balmer 1993; Paul and Hlupic 1994). "Web-enabled" simulation analysts will use these tools to assemble rather than build models.

Figure 2 shows a possible method based on assembly rather than build. In this the webber-analyst grabs and glues bits of the model that might be deemed sufficiently appropriate. Running the quickly assembled model enables its fitness for purpose to be established. If satisfactory, problem understanding is attained. If unsatisfactory, it is rejected and "grab-and-glue" is tried again. The webber-analyst follows this G^2R^3 approach (Grab-and-Glue, run, reject, retry) at a fast rate, getting insights during the G^2R^3 process and satisfying the stakeholders of the problem at a time acceptable to them. It is implicit in this approach that a G^2R^3 model would not necessarily have to mimic the real world in which the problem exists. The G^2R^3 model would only need to give appropriate outputs to some inputs to fulfill its purpose.

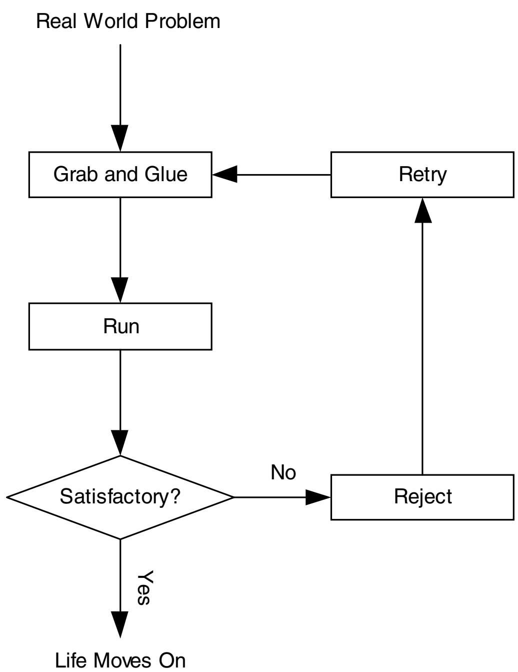

Figure 2: The G^2R^3 Process (Paul 2002)

Page et al. (2000) discuss these issues at length. Quality is raised as an issue, but of course no software can be "proved" correct in these circumstances. Why should modelers take so long to get an answer(s) from a "traditional" simulation model when that model cannot be proved to be correct. However, if it becomes possible to "glue" bits of a model together fast enough and experimentally, then we might see a shift of emphasis from "is the model correct?" to "is the analysis, albeit with unproven software, acceptable given the large experimentation that swift modeling has enabled us to carry out in a short space of time?" In other words, the search space might be dramatically reduced not by accuracy (the old way), but by massive and rapid search conducted by an empowered webber-analyst (the new way). Models are reused in this way without trust but as part of an intellectual process that fosters understanding. A pot of gold may yet exist!

5 CONCLUSIONS

This paper has discussed model reuse and has put forward the view, at least in the territory of COTS simulation modeling practiced by many in business, manufacturing, and health, that in its current form model reuse is no use. A noble cause to be sure, but those expecting a pot of gold at the end of the rainbow should not be surprised to find a crook! However, a G^2R^3 approach, one founded in problem understanding and not in the painstaking creation of a "valid" model, may arrest our crook and return to us the pot of gold that modelers richly deserve. Ultimately, G^2R^3 may prove impractical as there are many technological barriers to the use of the Web to support modeling, or the move away from a "traditional" approach to modeling may be too big a step for some. In some cases, applications such as production line planning, digital factories or virtual network supply chains may not be appropriate for methods based on G^2R^3. In any case, it is our hope that our presentation in this paper provides the basis for stimulating discussion on the future of model reuse. Further discussion on G^2R^3 can be found in Paul (2002).

It is hoped that these contributions, and others such as the regular UK Operational Research Society's Simulation Study Group and the GROUPSIM Network's forthcoming workshops on the adaptation of the High-Level Architecture for process-based modeling and simulation significantly advance the debate in this area (see `www.groupsim.com` for further details).

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AUTHOR BIOGRAPHIES

RAY J. PAUL is a Professor of Simulation Modelling, Director of the Centre for Applied Simulation Modelling, the creator of the Centre for Living Information Systems Thinking, and the Dean of the Faculty of Technology and Information Systems, 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 modelling 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 editor of the Springer-Verlag Practitioner book series. His research interests are in methods of automating the process of modelling, and the general applicability of such methods and their extensions to the wider arena of information systems. He is currently working on aspects of simulation in the social sciences, in particular health management, the new G^2R^3 modelling technique. His email and web addresses are <ray.paul@brunel.ac.uk> and <www.brunel.ac.uk/~csstrjp>.

SIMON J.E. TAYLOR is the Chair of the Simulation Study Group of the UK Operational Research Society and the collaborative simulation modelling forum, the GROUPSIM Network (www.groupsim.com). He is a Senior Lecturer in the Department of Information Systems and Computing and is a member of the Centre for Applied Simulation Modelling, both at Brunel University, UK. He was previously part of the Centre for Parallel Computing at the University of Westminster. He has an undergraduate degree in Industrial Studies (Sheffield Hallam), a M.Sc. in Computing Studies (Sheffield Hallam) and a Ph.D. in Parallel and Distributed Simulation (Leeds Metropolitan). His main research interest is collaborative simulation modelling. He is also a member of the Purple Theatre Company. His email and web addresses are <simon.taylor@brunel.ac.uk> and <www.brunel.ac.uk/~csstsjt>.