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Framework of a Conceptual Simulation Model Design Tool

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Abstract

Computer simulation is an efficient tool for addressing problems related to complex systems. To ensure a successful simulation study, a systematic project management is the most important factor. This initially requires a proper conceptual model design. However, the importance of a precise conceptual model design is often overlooked, and there is currently no conceptual design tool for field engineers. To address this problem, this paper proposes a framework for a conceptual simulation model design support tool that includes an automatic model generation feature. The components of the conceptual model are defined, and the proper conceptual model design process is examined to present the desirable development concept of the conceptual model design support tool.

Keywords: Automatic Model Generation, ARENA, Conceptual Model Design Tool, Simulation

1. Introduction

Computer simulation is an efficient tool for addressing problems related to complex systems. It is a management science technique that is widely used in the actual field, next to the statistical techniques and linear programming[1,2]. However, it requires a long time and high costs because it involves data acquisition, model development, tests, and statistical analyses. Accordingly, efficient simulation project management is important, including efficient conceptual model design[2]. The development of a simulation model that corresponds to the purpose with minimal trial and error especially initially requires an appropriate conceptual model design. Nevertheless, the importance of the conceptual design is overlooked and there is currently no conceptual design tool for actual practice. In addition, as the simulation software packages evolve from the computer-language-based coding into the graphic input type, the conceptual design stage is omitted or simplified. However, there is a question as to whether or not the graphic input type is helpful for large-scale model development[3]. In the modeling based on the graphic input, which is used in recently launched simulation software programs such as Arena, Any Logic, Flex Sim, Pro Model, and Witness, even a novice can have easy access to the model without knowledge of the simulation-based programming language, but the importance of simulation models based on precise logic is relatively overlooked. Therefore, the development of a simulation model using a simulation software requires a conceptual model design tool that supports precise model development, taking advantage of the graphic input. This paper proposes a proper framework for such a tool. Previous studies on the conceptual simulation model are often related to the automatic creation of models or program codes[4–7]. This study was conducted mainly to broadly develop a conceptual model design support tool with an automatic model creation feature. To the best of the author's knowledge, although there have been studies on the conceptual model, this is the first full-fledged study on the support tool. There have been studies on the overall conceptual model design, including the studies of Law and Robinson[8,9].

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They stated that an effective conceptual model design is the most important aspect of a simulation study, but is difficult and has not been deeply studied yet. Accordingly, there are few studies on it, and it was difficult to find literature that had details on the conceptual model design. According to Robinson and Pace, a well-developed conceptual model provides a great means of communication between model developers, simulation-related customers, and persons in charge[9–11]. Through the development of the conceptual model, agreements can be made on the essence and usage of the model. The main components of a conceptual model are the problematic situation (basis of the conceptual modeling), the objective of the project, the inputs (experimental factors), the outputs (responses), and the model contents (scope and level of details). This study proposes a framework of the Conceptual Simulation Model Design (CoSiM) support tool, which has an automatic Arena simulation model creation feature and the aforementioned model components. Arena is the most widely used simulation software worldwide. To give many users easy access to it, CoSiM has a frame that uses the Visual Basic Application (VBA) based on Microsoft Office 2010 Excel and Visio. This paper is organized as follows. In section 2, the frame of CoSiM is discussed in the categories of project management, data module design, and flowchart module design. Section 3 describes the automatic simulation model creation feature. Finally, in section 4, conclusion and direction of further studies are provided.

2. CoSiM Framework

2.1 Overall Summary

CoSiM consists of the features such as project management, data module design, and flowchart design module. The first two features are implemented in Excel (we call this part as CoSiM Excel), while the last one is implemented in Visio (CoSiM Visio). Note that an Arena simulation model consists of the data module for defining the data and the flowchart module for modeling the process[12]. Figure 1 shows the layout of the CoSiM Excel screen. The ribbon menu of the Excel CoSiM tab allows access to the appropriate functions. The menu of CoSiM is divided into three parts. Each menu has sub-menus that provide additional functions as needed. Table 1 shows the menu of CoSiM.

CoSiM Excel supports the overall management of the simulation project, from file management by project to schedule and team member management. In addition, the definition of the simulated system can be recorded, and tables are provided to the components of the model so that the data module for simulation modeling can be defined and managed. After the compatibility test, the data module is used in the conceptual modeling for the flowchart module. Next, in CoSiM Visio, the data module defined in CoSiM Excel is used to design the conceptual model following the activity diagram[12]. In addition, a function for verifying the conceptual model is required for precise conceptual modeling and automatic Arena simulation model creation. This feature has the functions of verifying the data module and checking the logic of the process in the flowchart module. The organization of the conceptual model designed using CoSiM Excel and Visio is recorded in the CoSiM-exclusive database (DB). To minimize the design error, the CoSiM Excel and Visio designs must be synchronized. Finally, CoSiM has the function of automatically converting the designed conceptual model into the Arena model. After the conceptual model created using CoSiM Excel and Visio is converted into the DB in the Arena format, the 'Import Model from Database' command of Arena can be used to automatically create the model. Through the design process with CoSiM, the user can minimize trial and error in the development of a precise conceptual simulation model, easily communicate with team members on the model, and simplify the simulation modeling work.

2.2 Project Management Feature

A successful simulation project requires definition of the overall project, including the project schedule and team members, and clear understanding of the simulated system and its objective. CoSiM Excel has functions that manage the overall project details in the conceptual model design. The project information menu provides the user with an exclusive worksheet for managing the basic information on the project. Such worksheet is shown in Table 2.

Next, the problem definition menu should allow the definition and management of the simulated system in the conceptual model design. Table 3 shows the items to be addressed. In addition, the performance indicator menu should allow the registration and management of the per

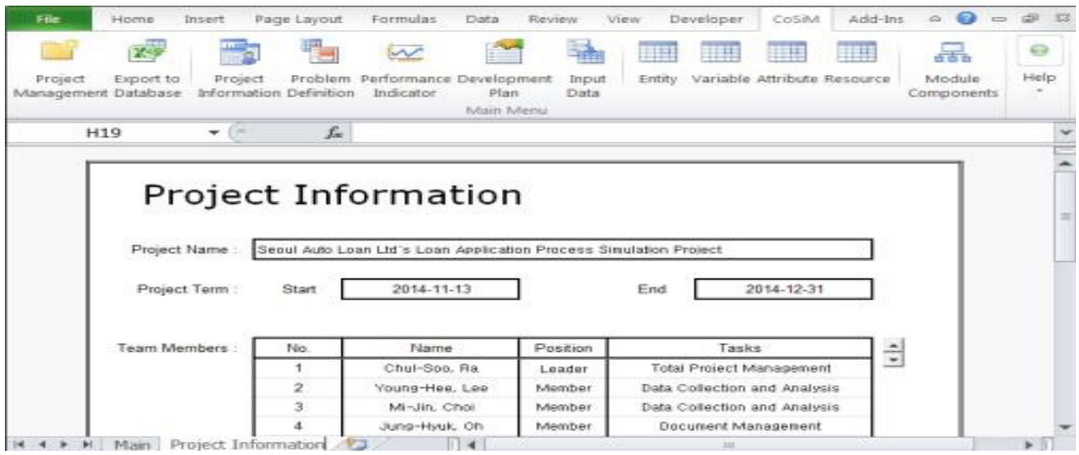


Figure 1. Screen layout of CoSiM Excel.

Table 1. Menu of CoSiM Excel

Menu Name	Description
Project Management	Manages the CoSiM files by project
Export to Database	Stores the CoSiM information in process in the exclusive DB
Project Information	Manages the basic information on the project
Problem Definition	Manages the problematic situation and objective of the simulation
Performance Indicator	Manages the performance evaluation criteria
Development Plan	Manages the development plan of the simulation model
Input Data	Manages the external data file
Entity	Verifies the definition and validity of the entity
Attribute	Verifies the definition and validity of the attribute
Variable	Verifies the definition and validity of the variable
Resource	Defines the resource and resource set, and verifies the validity
Module Components	Manages the flowchart module files created using CoSiM Visio and converts the DB to create the Arena model

Table 2. Managed project information items

Classification	Description
Project Name	Name of the simulation project
Project Term	Start date and end date of the project
Team Members	Members of the project and their positions and assignments
Model Naming Convention	Nomenclature for the simulation model components
Editing Tools	Document editor for the project
Project Description	Overall contents of the project

formance evaluation criteria for the simulation model in the conceptual model design. Each performance evaluation criterion should be explicitly defined in the CoSiM Excel, along with the details, and the external document files with expressions should be registered and managed.

Since the model design takes a long time, the detailed model development plan should also be recorded and managed during the simulation project process. The development plan menu is used to record the step-by-step development plan for the entire model development, the

Table 3. Managed project definition items

Classification	Description
System Definition	**Clear definition of the simulated system**
Context Diagram	**Registration and management of the file that schematizes the system flow**
Simulation Objectives	**Objectives of the simulation project**
Simulation Scope	**Definition of the scope of the simulation modeling**
Assumptions	**Assumed technology applied to the simulation model development and its management**
Drawing	**Registration and management of the drawings and charts that help explain the system**
Simulation Alternatives	**Information on alternatives and Arena files for each alternative in the hyperlink form**

Table 4. Managed data module items

Data Module	Description
Entity	**Defines the object and includes the expression name and the additional description**
Attribute	**Defines the attribute of the object and includes the expression name and the additional description. Design of the size of the row and column of the attribute, initial value, and range**
Variable	**Defines the system variable and includes the expression name and the additional description. Design of the size of the row and column of the attribute, initial value, and range**
Resource	**Defines the resource and includes the expression name, additional description, and capacity**
Set	**Defines the resource set and includes the expression name and the additional description**

descriptions of each step, the objective completion date, and the main checkpoints. With the development plan menu, users can modularize the entire simulation model for design and development during the conceptual model design process. Moreover, if the entire model is huge, it supports gradual design according to the development plan to eventually complete the entire model. Finally, the collected input data should be managed using the input data menu. The names and descriptions of the data should be recorded, and the data files should be registered and managed.

2.3 Data Module Design Feature

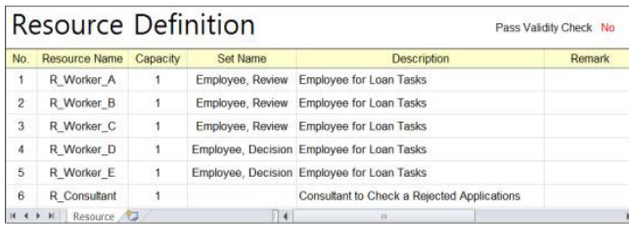
The conceptual model design supporting tool must allow the user to directly define the data module and check whether it can be applied to the simulation software. CoSiM Excel manages five data modules (entity, attribute, variable, resource, and resource set) using the exclusive worksheets, and has a validity verification feature that allows the use of the designed data module in Arena. Table 4 shows minutely the items that must be managed. In Arena, alphanumeric characters are used to name the model components. Special characters conform to the rules of the Arena. The rules for the Arena symbol name are as follows:

- Limited to alphanumeric strings
- Special characters such as @, _, %, ?, #, <period>, and <space> allowed
- Punctuation characters not allowed
- Reserved words not allowed

CoSiM Excel checks the validity of the user-defined data module according to the aforementioned rules. If the user's inputs are incorrect, the rules of the Arena symbol name are presented. The user-defined data module is also used to design the activity diagram using CoSiM Visio, and applied to the Arena model as it is, in cases of conversion into the simulation model. Figure 2 shows the resource definition as an example of the data module.

2.4 Flowchart Module Design Feature

The conceptual model design supporting tool should allow the user to implement the flowchart module in Visio based on the data module defined in Excel to create the activity diagram. In CoSiM Visio, the user can use the shape to design the conceptual model, and verify


Resource Definition

Pass Validity Check No

No.	Resource Name	Capacity	Set Name	Description	Remark
1	R_Worker_A	1	Employee, Review	Employee for Loan Tasks	
2	R_Worker_B	1	Employee, Review	Employee for Loan Tasks	
3	R_Worker_C	1	Employee, Review	Employee for Loan Tasks	
4	R_Worker_D	1	Employee, Decision	Employee for Loan Tasks	
5	R_Worker_E	1	Employee, Decision	Employee for Loan Tasks	
6	R_Consultant	1		Consultant to Check a Rejected Applications	

Resource

Figure 2. Resource definition worksheet

the validity of the designed diagram using the check validity button in the ribbon menu. CoSiM Visio provides the 21 shapes in Figure 3 for the implementation of the flowchart module in the conceptual model design. Twelve of the shapes are module shapes, and have exclusive input forms. The module characteristics can be inputted and stored as in the flowchart module of Arena, and their characteristics are summarized and displayed in the conceptual model. The other nine shapes are connection shapes, which represent the connections between the module shapes. Table 5 describes the flowchart module shapes of CoSiM. I

n CoSiM, if the developer completes the design and records as shown in Figure 4 using the shapes in Table 4, the relevant design using the flowchart module shapes of CoSiM Visio based on the data modules designed using

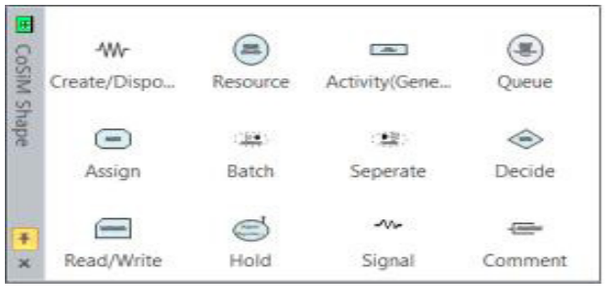


Figure 3. Visio shape for the implementation of the flowchart.

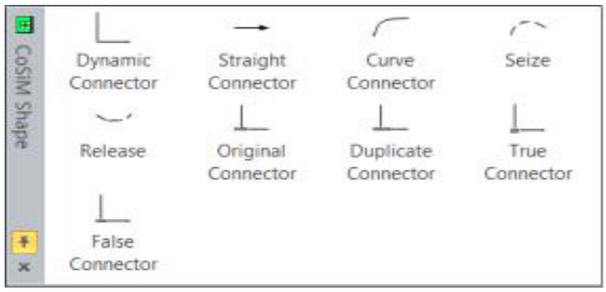


Table 5. Characteristics of the flowchart shape

Shape Name	Description
Create/Dispose	**Creation and disposal of the object**
Resource/Set	**Resource and set with capacity.**
Activity	**Activity of the object. Delay time setting. Used with the Resource/Set and Seize & Release module.**
Queue	**Queue matrix required for the Activity, Hold, & Batch module. The type of queue can be set.**
Assign	**Assigns values to the attribute and variable.**
Batch	**Batch of objects. Sets the batch type, size, and batch rule. If the batch rule is by attribute, the appropriate attribute value is set.**
Separate	**Separation of the object. Sets the separation type and number of the replicated objects.**
Decide	**Ways of the object. Sets the type (Chance or Condition).**
Read/Write	**Data input/output. Sets the input/output type (Excel, Ascii file, etc.).**
Hold	**Standby state of the object. The hold type and the resulting additional attributes (Wait for value, limit, etc.) can be set.**
Signal	**Signal transferred to the hold module.**
Comment	**Comments or memos.**
Dynamic, Straight & Curved Connector	**General flow of the object.**
Seize & Release	**Occupation relationship between the activity module and the resource.**

information is displayed in the flowchart along with the shapes. Thus, the user can design the conceptual model Excel. The conceptual model is first designed by the system module according to the defined development plan. After the review and modification, the final conceptual model is completed. Figure 5 shows an example of the conceptual model completed using CoSiM. The conceptual model provides an overall explanation of the simulation model and allows easy communication with project team members on the descriptions in the design document.

Figure 4. Flowchart design of the Create module.

Synchronization problems may occur between the data module in Excel and the flowchart module in Visio. For example, the defined but deleted data module may still exist in the flowchart of Visio. Therefore, a feature for synchronizing data modules between Excel and Visio must be provided to prevent such user errors in the conceptual model design process. To achieve this, in CoSiM, the data in the current DB and Excel are automatically compared when the program starts/ends; and if there are changes, the user is informed so that he/she can export the changes to the DB. CoSiM Excel conducts synchronization checks after CoSiM starts, before it ends, and after it has exported the data module. When all the data modules (Entity, Attribute, Variable, Resource, and Set) in the worksheet and the CoSiM DB do not match, the user is informed with a message (Figure 6) so that he/she can export the current worksheet for synchronization. When the flowchart is created in CoSiM Visio, the update of the data module in Excel should automatically trigger the flowchart module; and when any data module not defined in Excel is used, a report should be provided to the user. The user can refer to the provided error report to directly modify the flowchart module. If incorrect data modules have been used in multiple flowchart modules, they should be modified simultaneously to ensure easy correction of synchronization errors.

In addition, CoSiM Visio conducts synchronization checks after CoSiM Visio starts, before the flowchart check of CoSiM Visio, before CoSiM Visio exports the flowchart data to the DB, and when the shape is double-clicked and the form of the appropriate module is opened. In the first three cases, the user should be provided the synchronization check results according to the algorithm in a text file to ensure easy correction. To ensure the easy modification of the designed module, if Excel and Visio are not synchronized when the form of the module is opened from the shape, the user-specified data module is automatically searched for in the CoSiM DB. If the value does not exist, the change is displayed, and the user should choose to have the correction take (taking) effect in the appropriate module alone or in the entire module. The aforementioned synchronization feature in CoSiM allows the conceptual simulation model designer to accurately design the conceptual model and promptly change the design.

3. Automatic Arena Model Generation Feature

3.1 Logic Check of the Flowchart Module

CoSiM should have a feature for checking design errors in the flowchart before the automatic model generation, to allow correction of errors at the design stage before the simulation model creation, and user development of an accurate simulation model. For the validity check for the CoSiM flowchart, unique check algorithms for each shape of the flowchart module are needed. The connection information of a Visio shape commonly provides information on the connection between the shapes. The predetermined module characteristics and connection information allow checking by flowchart module. For example, if there is no linear shape connected to the assign module, the object cannot proceed. In this case, CoSiM creates an error message and provides it to the user in the form of a report. The items to be checked in the CoSiM validity check are divided into two categories. First, universal errors can occur across the system in any module. These errors include failure to connect modules correctly using linear shapes, and expression of a shape without entering the modeling characteristic. Second, module-specific errors occur for a logical reason because of the unique input value of the appropriate module.

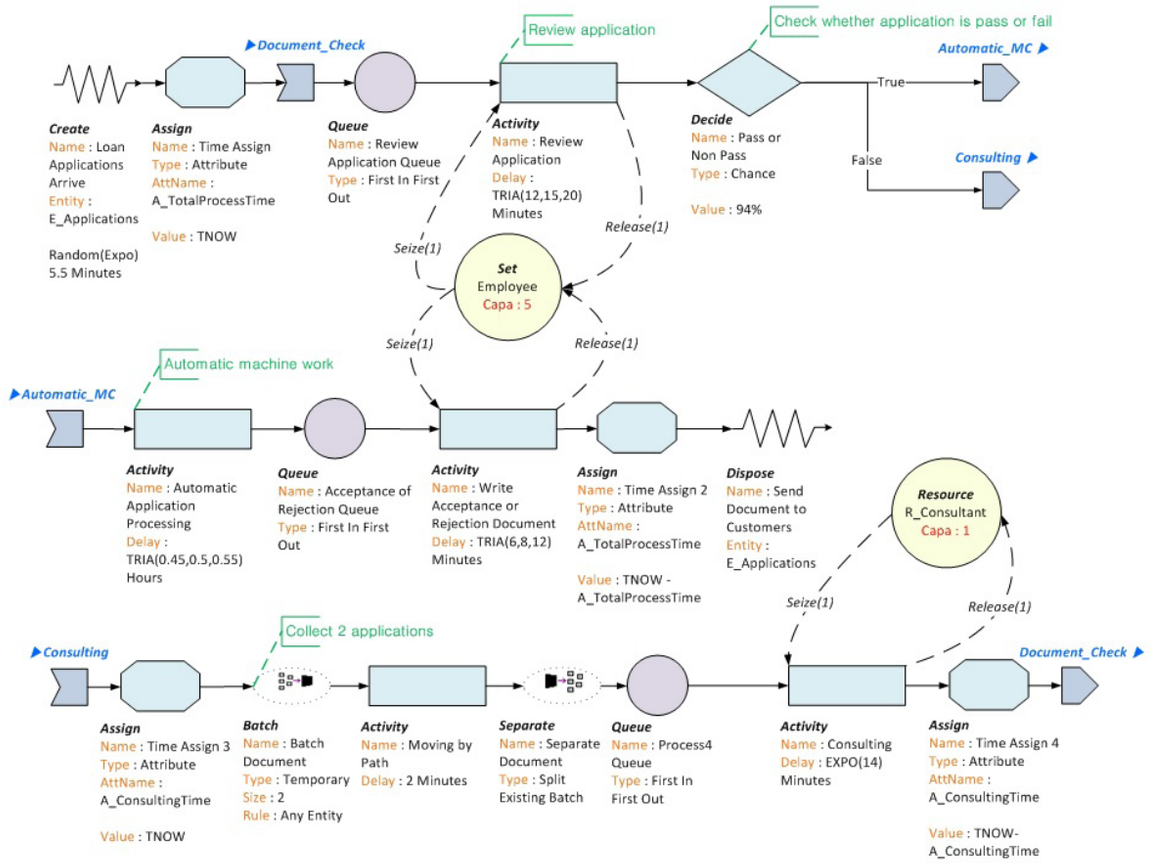


Figure 5. Example of the completed conceptual model design.

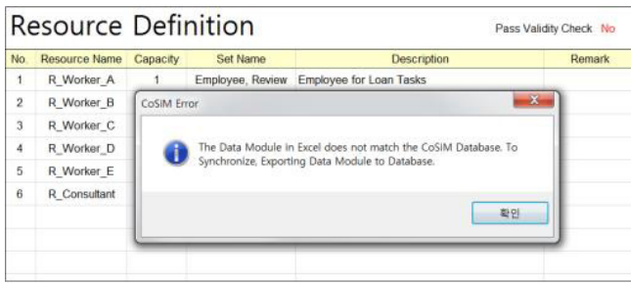


Figure 6. Synchronization error check of CoSiM Excel.

These errors include a design in which a greater amount than the capacity defined in the resource module is seized in an activity.

3.2 Automatic Arena Model Creation Feature

When all the contents of the conceptual model designed using CoSiM Excel and Visio are exported to the CoSiM DB, the DB will already contain enough information for the creation of an Arena model. In the 'Module Components' menu of CoSiM, the object names and module descriptions for a simulation model module are written, and the appropriate Visio file is registered as a hyperlink and managed. In addition, the appropriate module is converted into '.mdb' files that are compatible with Arena. Therefore, the user can convert the designed conceptual model into a simulation model using the "Tool-Import Model from the Database" feature of the Arena menu. Figure 7 shows the designed conceptual model shown in Figure 5, which was automatically converted into the Arena model.

4. Conclusion and Future Research

This paper proposed the components of a conceptual simulation model design tool, and presented the conceptual model design process. Based on the project detail management and data/flowchart module design and review,

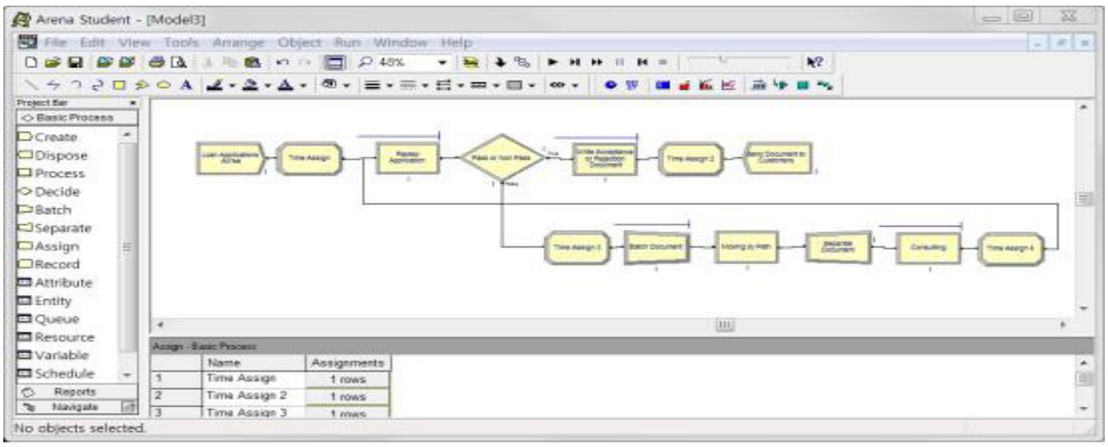


Figure 7. Conceptual model converted into the Arena model.

the simulation model is automatically created to ensure quick and easy yet precise model development. The framework proposed in this study is expected to help design a conceptual model of efficient simulation project operation. The limitation of this study is that it considers only the Arena software. Diverse simulation packages can be used in a simulation project, depending on the situation and objective. Further studies must address the development of a broad framework for a conceptual simulation model design tool that supports diverse simulation packages based on the proposed framework.

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