GRAPHICAL VISUALIZATION FOR THE MANAGEMENT OF SPREADSHEET SIMULATIONS

José M. Pastor[1], Javier Otamendi[2], Andrés García[3]

[1]University of Castilla-La Mancha, Polytechnic School
16071 Cuenca, España
[2]University Rey Juan Carlos, Faculty of Social Sciences,
Madrid, España
[3]University of Castilla-La Mancha, School of Industrial Engineering
13071 Ciudad Real, España

franciscojavier.otamendi@urjc.es (Javier Otamendi)

Abstract

The development of a tool for the allocation of resources to flights and airplanes at an airport is presented. The tool must have an interface in the widely available and used spreadsheet to exchange information with the user and present the results, specifically the required Gantt chart. The MsExcel spreadsheet is able to read the data about flights and available resources, simulate the operations using VisualBasic in order to find the best possible assignment of resources to the parking positions and show the utilization ratios and the time-based Gantt chart using a colour coding for the resources. The major contribution of this article is a second interface in the form of a visual environment so that both the static Gantt chart might be dynamically animated over part or the totality of its time horizon and the status of the airport is liable to be photographed at any point in time. A JAVA screen is added so the operations and the state of the resources might be dynamically visualized at four parking positions simultaneously when scheduling and programming the resources. The validation of the tool is being performed at a new international airport in Ciudad Real, Spain, which will begin operations by the end of 2007.

Keywords: spreadsheet simulation, resources allocation, Visualization, JAVA.

Presenting Author's biography

JAVIER OTAMENDI received the B.S. and M.S. degrees in Industrial Engineering at Oklahoma State University, where he developed his interests in Simulation and Total Quality Management. Back in his home country of Spain, he received a B.S. in Business Administration and a Ph.D. in Industrial Engineering. He is currently a simulation and statistics consultant and university professor. He collaborates with Autolog Group at Univ. Castilla-La Mancha, http://autolog.uclm.es.

ISBN 978-3-901608-32-2

1 Introduction

Spain is suffering important changes in the air service industries. Several new private airports are being built all over the country to attract low cost companies. Ciudad Real is a city located 200 kilometres south of Madrid and its airport is to start operations at the end of 2007. For that reason, the company is starting to develop tools that will help in the management operations with the aim of optimally allocating resources.

Project management is an old problem with known techniques and solutions. One of these main techniques is the Gantt chart, in which the utilization of resources is plotted over time. Its use is double-fold. On the one hand, a forecast is to be made at the beginning of the project on the use of the resources as well as on the total completion time. On the other hand, as the project goes along, a comparison of the current situation with the forecasted one will throw some light on possible corrective actions, which will as a result generate a new chart.

The first objective of the research is the graphical definition and representation of the operations that are going to be carried at the parking positions: embarking and disembarking of the passengers and the crew and all of the associated activities. The second objective, which will be studied in detail after the first one is completed, is the staffing and the dynamic scheduling of resources.

The visualization tool to be used is crucial to the success of the project. This tool is to be developed from the model and scheduling algorithm implemented in the MsExcel spreadsheet with Visual Basic. In most of the cases, the clients want that the input of data be performed in spreadsheets that they already handle and that the results appear in the same spreadsheets in different formats. It would be interesting that the visualization software could be controlled from the same spreadsheet.

Although fairly easy to develop and use, users are often asking for a more interactive tool to find satisfactory managerial solutions to the problem of scheduling and sequencing of the available resources. These decisions are both for the short-term, if they are to be made on the spot to assign a given resource to a certain task, or for the long-term, if they are to affect largely to the outcome of the whole project, like subcontracting or deciding on the total level of resources

These decisions call for software tools that are more user friendly than the project management tools available in the market, which usually goes as far as drawing the Gantt chart after reading the data from an outside source, but they are not able to provide the desired capabilities both in terms of simulation and visualization of the charts along time and in terms of experimentation with possible alternatives, like the level of resources.

In this paper, the emphasis is made in the development of the visualization tool that will be used to graphically show the results of a spreadsheet simulation. The two main objectives then are to select the graphical tool and to show a case example, in the demanding area of project management.

2 State of the art

Visualization and experimentation is the forte of simulation tools, although the commercial tools available for this type of software are usually neither focused on project management nor they are very user friendly. In fact, most of the available commercial packages have incorporated and rely heavily on their MsExcel connectivity to input data and to show results.

For that reason, users of the applications developed with commercial software are more and more reluctant to use the software directly and ask for the interface in the almost universally available spreadsheets. That is, they want to keep on working in their daily used, friendly environment, although they are willing to add simulation capabilities to their spreadsheets.

VisualBasic within MsExcel, for example, provides the tools to develop simulation models for relatively complex models, which are just executed by pressing a button on the main screen. In that same screen, it is possible also to facilitate the experimentation by including cells in which the possible range of feasible values of the decision variables might be specified and so are the aspiration and satisfaction values of the main criteria.

The problem with the spreadsheets is its lack of visualization; see [1] for advantages and limitations of spreadsheet simulations. In many cases, and once the experimentation phase is under way, a visual interface is not necessary since the only need and hope is that a good feasible solution is found within a reasonable experimentation time. But, while developing the model or while selling a solution to management or while performing the control tasks that a project requires, it is sometimes necessary to show a dynamic representation of the execution of the model. In those cases, the spreadsheet cannot usually compete with commercial simulation or visualization software.

In this point one of the options that is considered for the dynamic representation of the model is to use commercial simulation software, whose visualization could be executed easily from the spreadsheet. The problem is that the user would have to know how to handle the module of visualization of the chosen software, whether it is ARENA, Witness, AutoMod, etc. Additionally, proprietary software has to be included in the final solution with the disadvantage of the license costs.

ISBN 978-3-901608-32-2

This first option would require to program in Visual Basic the interaction between the spreadsheet and the simulation software. The execution of the simulation tool will be controlled from menus and buttons in the spreadsheet.

One second option would be to develop the visualization tool using the objects library included in some of the commercial packages. The programming language for the application could either be Visual BASIC, or C++ or C#. In this case we still depend on proprietary software but the tool could be designed in accordance with the user necessities.

The third option would be to program the visualization tool using standard libraries. Between these we can emphasize: GDI, OpenGL, DirectX and Allegro, available for Windows and Linux environments in different languages. This would allow programming the visualization tool in any language. In this third option we can include the programming in JAVA language and its graphical libraries AWT and Swing.

Finally, the fourth option would be to use a graphical library of programming oriented to virtual reality in the Web like VRML. In this case the programming language JAVA is the better option.

3 Description of the problem

Don Quijote Airport is the first private international airport in Spain, amounting a total investment of 1.1 billion euros. It represents a pioneering project, which will start operations by the end of 2007.

Don Quijote Airport offers a wide variety of services: domestic and international commercial aviation (charter and scheduled flights); cargo dedicated facilities (perishables and dry cargo); GA especially-designed premises; aircraft maintenance services; long-term aircraft parking area; heliport; and, furthermore, a spacious industrial area expanding over 800 hectares which complements and takes full advantage of all the synergies arisen out of the aeronautical services operation.

Thanks to its location adjacent to the Madrid-Seville high-speed train line and its train station attached to the passenger terminal, passengers will be situated just 45 minutes away from Madrid city centre and Cordoba. Besides, it has been conveniently located in connection with the main Spanish highways network.

Madrid airport is one of the most expensive for companies to operate in, due to plane-parking limitations and air-traffic jams. Ciudad Real airport is called to sort some of the traditional air-traffic problems in the Madrid area. Plane maintenance operations will transfer to Ciudad Real as well as some commuting and trans-Atlantic flights. Low-cost companies will prefer Ciudad Real due to lower prices and location convenience, as it can be used for passengers going to the south of Spain (mainly for seasonal movements) as well as for those visiting Madrid.

All this allows forecasting that Ciudad Real airport will undergo a fast growing process form its setting in operation at the end of 2007 and along its first five years; as well as important seasonal variations in traffic. This situation will require the development of easy-to-use tools that can provide support to the management team with different operations, as shown in [2].

4 Description of the tool

For the development of the tool, it has been decided on the third option exposed in the state-of-the-art, with graphical standard libraries, thinking about avoiding the proprietary software that adds an excessive cost and reduces flexibility. The option of the virtual reality library has been discarded because it has been decided initially to use two dimensions graphics, but is an excellent option to develop visualization in three dimensions without a high level of complexity.

The chosen option to integrate the different applications such as the simulation algorithms and the simulation model is the spreadsheet, so that this is the only interface with the end user. See [3] as an example of spreadsheet simulation.

In the main sheet, the main input data related to the flights is included: company, flight number, arrival time/date, departure time/date, as shown in Fig. 1.

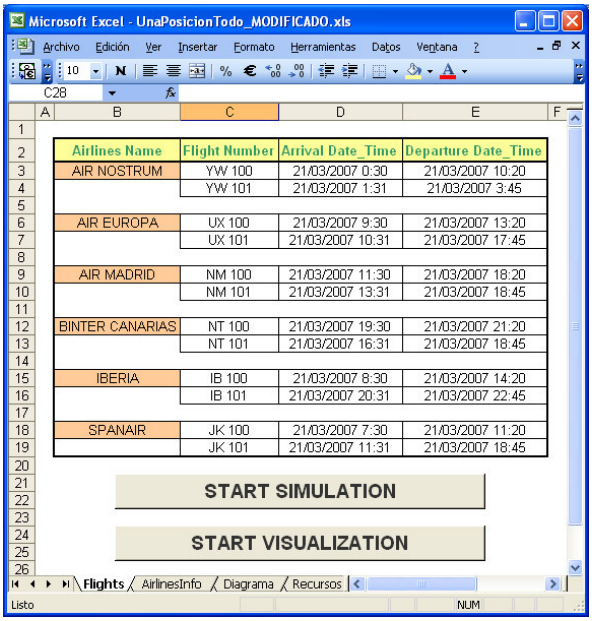

Fig. 1 Data of flights

The first auxiliary sheet includes the data of the resources: name, description, number of available resources, shifts, etc. The second auxiliary sheet will contain the data of the processes that are made on an airplane since it is going to land until it has taken off: diagram of activities, times, resources, etc., as shown in Fig. 2. Some of these processes are: boarding and

disembarkation of passengers, embark and disembarkation of crews, embark and disembarkation of luggage, maintenance services of the airplane, etc.

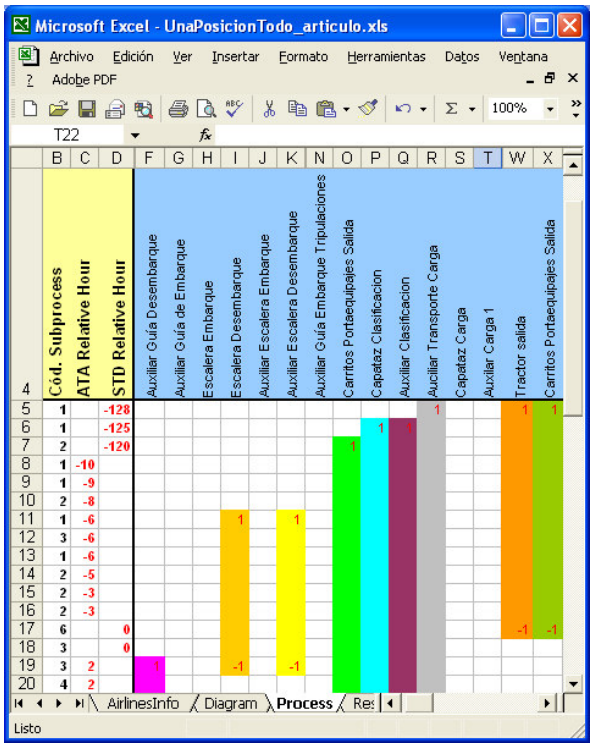

Fig. 2 Process Data

Another series of auxiliary sheets is used for the intermediate calculations and data that are necessary to execute the algorithms of simulation in Visual Basic. These sheets will remain hidden to the end user.

Finally, a set of results sheets of the simulation is also generated. Among them one of the most used for the decision-making is the Gantt chart, like the one shown in Fig. 3. Other gathered data are the percentage utilization of resources: histogram of resources occupation, fulfilment of the flights schedule, etc.

With relation to the visualization tool, JAVA has been selected as the visualization tool due to its good graphics capabilities and its easy connectivity with spreadsheets. The AWT and Swing libraries for JAVA have been used to develop GUIs and graphics.

The JAVA application that has been developed is executed after the spreadsheet simulation, which, using the VisualBasic routines, generates a Gantt chart with the operations to be performed per resource. It gives the user several visualization possibilities that range from the static representation at a particular time to the dynamic representation of part or the totality of the time horizon reflected in the Gantt chart.

Java is an object oriented programming language developed by Sun Microsystems at the beginning of the 90s. The Java applications are precompiled in a .class file, which is later interpreted during run time, allowing then for to the separated distribution of the program and the source code.

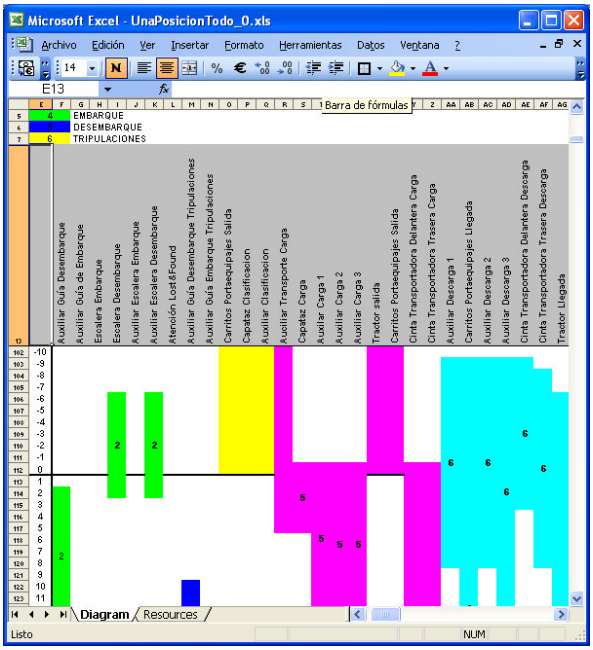

Fig. 3 Output Data, Gantt Chart

In addition, the JAVA applets permit the execution and the development of applications via WEB, which would allow to visualize the simulations from different computers.

Sun Microsystems provides a General implementation GNU Public License of a Java compiler and a virtual machine Java for all the platforms, which turns the application runeable under any operating system.

Therefore, Java has been selected because of its following fortes:

1. Good graphical capabilities.

2. Connection with Excel.

3. Allows for the execution of the same program in multiple operating systems.

4. Uses the methodology of the object-oriented programming.

5. Easy to use.

6. Integrated network tasks.

7. Availability of documentation, libraries, examples that facilitates the applications development.

8. Very popular language in academic environments.

Our tool tries to solve the problem of the administration of the resources of Ciudad Real's airport. This problem, partly solved by the Gantt charts, has one better solution with the visualization in real time of the management of the resources in the airport.

In Fig. 4, the interface of the application initially developed to visualize the processes and resources

required to take care of one parking position in the airport is presented. In the left frame the resources available appear. In the right frame the parking position of airplanes appears and so are the resources that are currently been used. In the lower frame, the reproduction controls of the simulation and a pair of informative panels appear.

Fig. 4 Application interface for one parking position

The application obtains as input data the Gantt charts and the times of departure and arrival of each flight using the clsReadXL class which imports data from Excel files. The diagrams manage the availability of 57 types of resources in the airport such as stairs to board or the coordinator of the track.

Fig. 5 shows the structure of the most important classes that compose the JAVA developed application.

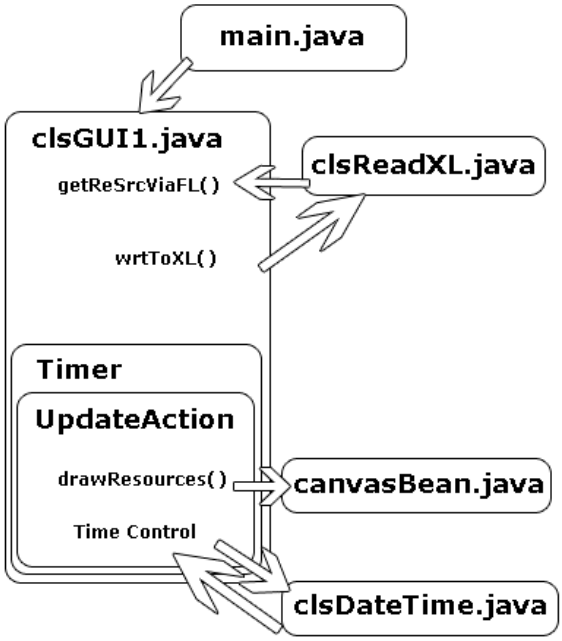

Fig. 5 Application interface for one parking position

Because the departure time of an airplane is variable, each one of these resources calculates its state at every moment referencing either the arrival or the departure time of the flight (the boarding stairs will make reference at the departure time whereas the attention of lost suitcases makes reference to the arrival time).

For the implementation of the GUI we used the Swing platform. The main window contains a reproduction control, a panel with the simulation parameters and four visualization panels, as shown in Fig. 6:

- The reproduction control is composed of 7 easy to use buttons:
  - Parameters of simulation:
  - Date of beginning: Start date and time for the simulation.
  - Final date: End date and time for the simulation.
  - Speed: Number of steps of simulation per second of real time.
  - Step: Minutes by step
  - Present hour: Simulation time
- The simulation window shows the contour of the airplanes and the engaged resources in the form of icons.

When an airplane begins to engage resources, before landing, a dock (a visualization panel) is reserved. The dock is not freed for another airplane until the last resource has finished.

With relation to the example, a real case study is going to be used. The simulation model represents the operations that are going to be carried in the parking positions of the new international airport in Ciudad Real: embarking and disembarking of the passengers and the crew and all of the associated activities, like movement of stairs.

The management of the airport desires that the application tool will be used in five different ways. The first one is the drawing of the traditional Gantt chart out of the data that is available on the spreadsheet.

The second one is the static visualization of the situation at the parking position at a specific moment in time. The third calls for the simulation of the Gantt chart, with the visual representation either on or off. The fourth one relates to the showing of results about utilization and completion times on the screen. Finally the fifth one looks for a proper experimentation tool.

ISBN 978-3-901608-32-2

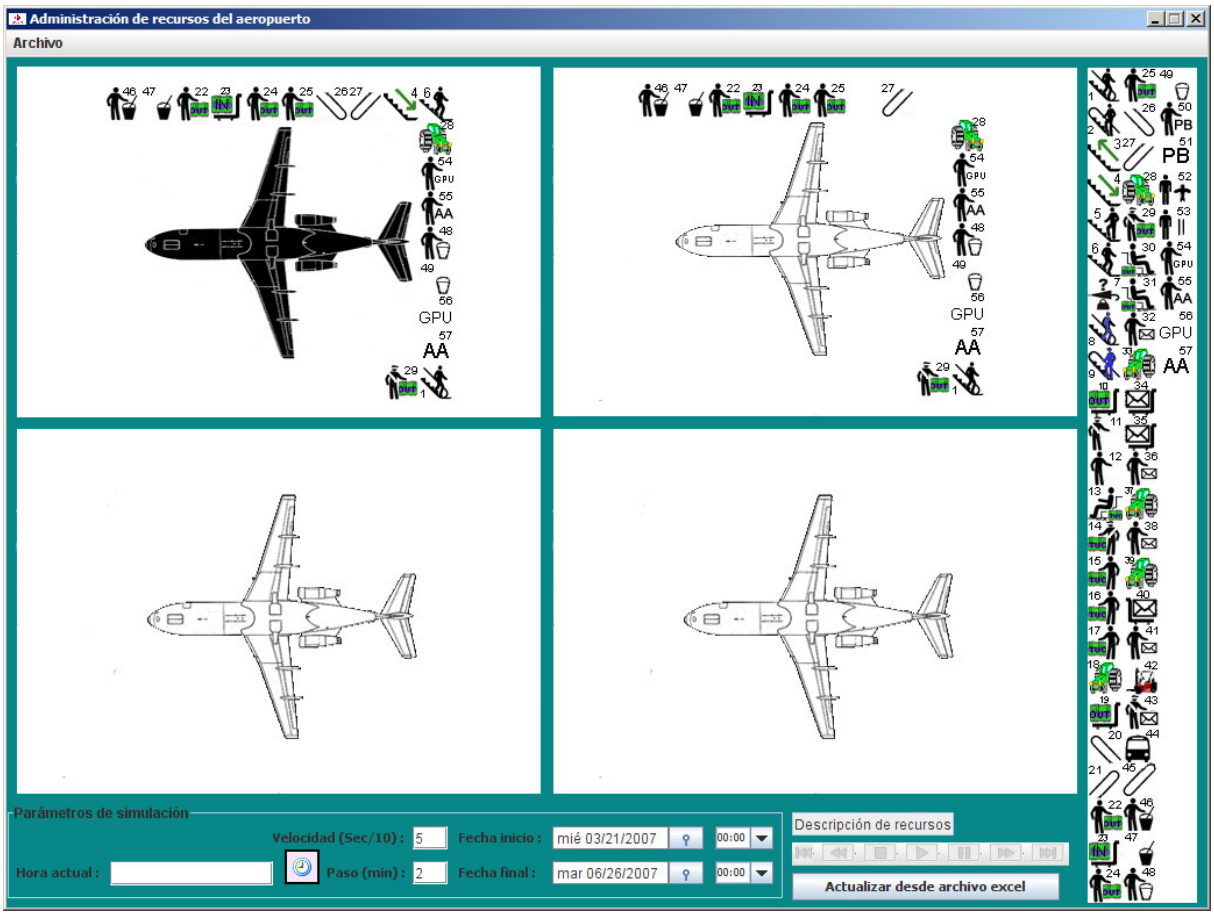

Fig. 6 Application interface for four parking positions

5 Conclusions

A tool for the dynamic visualization of the simulations performed in spreadsheets for the operations carried on the airplanes in an airport has been developed.

For the application development the language JAVA has been chosen using the graphical libraries AWT and Swing.

In parallel all the simulation interface has been developed on spreadsheets, where all the input data are introduced and the results of the simulation are generated. The simulation algorithms have been programmed with the Visual Basic language within the own spreadsheet.

The visualization tool has the possibility of implementing on it the simulation algorithms in such a way that it reads the input data from the spreadsheet and stores the obtained results in the spreadsheet.

The application will be used to analyze the optimal level of resources offering a good quality in the service to the airline companies.

The future work will consist of using the tool to make a pursuit of the operations in the airport and to decide the resources allocation of dynamic form.

This project is sponsored by the Regional Council of Education and Science of the Junta of Communities of Castilla-La Mancha [4].

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