Abstract: Business Process Simulation (BPS) is a rapidly emerging application area of discrete-event simulation that has gained considerable recognition in recent years as an enabler in enterprise engineering efforts. This paper reports on a case study where discrete-event simulation models of business processes were elaborated and executed to assist the management decision making of the initiation of a call centre application and furthermore decide on parameters affecting its operation and customer service level. To achieve this goal, the ARIS Collaborative Suite of tools was deployed. In the Enterprise Modelling level, ARIS offered a structured architecture and a variety of methods (models) for process mapping and simulation model elaboration. Down to the process planning and control level, it was ARIS simulation that provided the project team with the necessary simulation (dynamical execution of extended event driven process chains and organisational charts) and reporting capabilities that supported the final management decision.

Key-Words: Business Process Simulation, Process Modelling, ARIS Architecture, Call Centre.

1 Introduction

Technology plays an important role in the way organizations conduct their operations. As advances in technology have been made at an exponential rate over recent years, the dependency of businesses on information technology has increased as well. Enterprise engineering is defined as that body of knowledge, principles, and practices having to do with the analysis, design, implementation and operation of an enterprise. In a continually changing and unpredictable competitive environment, the enterprise engineer addresses a fundamental question: how to design and improve all elements associated with the total enterprise through the use of engineering and analysis methods and tools to more effectively achieve its goals and objectives.

Computer-based simulation is a well-established technique that allows systems (e.g. manufacturing, business processes, computer networks) to be modeled in a dynamic way and permits controlled experimentation on the model that would not be possible (or advisable) on the real-life system. This enables various alternative scenarios to be compared without the expense and disruption of fully implementing the proposed changes. This is one of the main advantages of simulation modelling but as a result of this, it produces other advantages over static modelling tools. Firstly, it allows bottlenecks or problems within systems to be identified along with their underlying causes. By allowing the various factors that could produce the bottleneck to be varied independently and then analyzing the effect, underlying problems can be eliminated. Secondly, depending on the domain, many models can be run much quicker than real-time which allows long-term effects to be studied. This can be especially useful in systems that have long cycle times. Finally and perhaps most importantly in the case presented in this paper, simulation allows for the identification of implicit dependencies between various parts of the system.

The instantiation of Business Process Simulation (BPS) in the process engineering level is Business process simulation software. BPS software is designed to emulate the dynamics of processes and display it graphically, thus indicating visually problems within the system.

This introduction is followed by a literature review of enterprise modelling and call centre simulation. Chapter 3 provides the reader with a
short overview of the ARIS Architecture. The case study is presented in Chapter 4 while in Chapter 5 conclusions and further research possibilities are presented.

2 Literature Review
A historical analysis of the emergence of enterprise modelling identifies its early roots within the software engineering community [18]. The close link that process modelling has with other conceptual modelling domains (such as data and object-oriented modelling) is evident, both within the literature and in the design of popular process modelling tools and practices [18], [14]. In the literature, there are four main enterprise modelling architectures that are applied to examine organizations: Open System Architecture for CIM (CIMOSA), ICAM (Integrated Computer Aided Manufacturing), GRAI (Graphs with Results and Actions Inter-related) and ARIS (Architecture of Integrated Information Systems).

CIMOSA CIM Open System Architecture [5], provides a process oriented modelling concept that captures both the process functionality and the process behavior. It supports evolutionary enterprise modelling, e.g., the modelling of individual enterprise domains which may contain one or several individual processes.

The Air Force’s Integrated Computer Aided Manufacturing project offers a suite of IDEF (ICAM DEFINITION) modelling methods, from function modelling (IDEF0), information modelling (IDEF1), data modelling (IDEF1x), systems dynamics modelling (IDEF2), process description capture (IDEF3), object oriented design (IDEF4), and ontology capture (IDEF5), among others. IDEF was derived from a well established graphical language known as structured analysis and design technique-SADT [16].Colquhoun and Baines [6], and Bravoco and Yadav, [3] provide a comprehensive discussion on the use of IDEF0 in developing manufacturing-oriented models. Sarkis and Lin [17], discuss the application of overall enterprise modelling for CIM strategic implementation. IDEF methods are used to perform modelling activities in support of enterprise integration [12], [13].

GRAI-GIM (GRAI Integrated Methodology) has been developed by the GRAI Laboratory of the University of Bordeaux [7], within the framework of the ESPRIT Projects Open CAM and IMPACS. It contains a user-oriented method and a technically-oriented one. The user-oriented method expresses user requirements specification in terms of functions, information, decisions and resources. The technically-oriented method transforms the user specifications into technical specifications in terms of information and manufacturing technology components needed to implement the system.

Finally, the ARIS architecture is a direct descendant of CIMOSA. A detailed description of the ARIS architecture is carried out in the next chapter.

Business Process Simulation (BPS) has been mentioned by many researchers as a technique that could be helpful in the context of business process change. For instance, Lewis [15] in one of the first articles specifically concerned with discrete-event simulation of business processes, investigate the suitability of simulation for reengineering projects.

Moreover, especially when combined with graphical animation and interaction capabilities, simulation facilitates better understanding of a system's behavior and of the impact of proposed changes, and allows for better communication of results. Managers and non-specialists can view a graphical layout of the proposed changes and understand the anticipated benefits more efficiently than would be possible with other modelling tools (for example, static flowchart models or spreadsheet financial analyses).

The authors argue that simulation is well suited as a design assessment tool in the context of evaluating process change alternatives. Furthermore, Kettinger et al., [11] argue that there is a need for more user-friendly and ‘media-rich’ capture of business processes which simulation can accommodate by providing easy visualization and allowing team participation in process redesign. Deeper analysis of Business Process Simulation shows that it has been widely used in the organizational domain, and the advantages of simulation presented by Banks et al., [2] work suggest that BPS is suitable to address at least the functional, behavioral and organizational perspectives.

Applications of call centre simulation models have been reported in different industries: airlines, telecommunications, the IRS, laboratories, hospitals and call centres [1], [4] [8], [9], [10]. However, few of them have the appropriate user interface permitting an easy experimentation of any element of the business system, a visual representation of the alternative scenarios’ results, enabling the easy organisational buy-in and their systematic use by top management for decision making.

It is the authors opinion that the case presented in the next chapters provides a smooth integration of a holistic enterprise modelling architecture with the powerful functionality and demonstration features of
a business process simulation software tool, such as ARIS Collaborative suite 6.2. In the next chapter a short description of ARIS modelling architecture is given.

3 The ARIS Architecture

The conceptual design of the Architecture of integrated Information Systems (ARIS) is based on an integration concept which is derived from a holistic analysis of business processes. The result is a highly complex model which is divided into individual views in order to reduce its complexity (Function, Data, Control, Organisation views). These views are consisted of three different project implementation stages that form the whole information system implementation life cycle. The result is the ARIS House of Business Engineering, shown in Figure 1.

![Image of ARIS House of Business Engineering](image)

Fig. 1: The ARIS House of Business Engineering

ARIS-House of business engineering (HOBE) enhances the ARIS process architecture by addressing comprehensive business process management, not only from an organisational, but also from an IT perspective [18].

Therefore, ARIS HOBE provides a framework for managing business processes -- from organisational engineering to real world IT implementation, including continuous adaptive improvement. In the next chapter, the implementation of a combined call centre modelling and simulation approach based on ARIS disciplines will be presented.

4 Case Study - Integrated Systems S.A.

The case study presented is a company from the Greek Information Technology sector, Integrated Systems S.A. (disguised). Integrated Systems was founded in 1987 and is currently one of the biggest and most rapidly developing Greek companies. Integrated Systems is spanning its activities in the following business areas: Distribution of ICT Products & Solutions, IT Business Solutions & Applications and Technical Support & Services. The company occupies 50 people and is located 25 km from the center of Athens.

This paper presents a study carried out on behalf of the industrial user in order to determine the various parameters of implementing a Call Centre business unit serving customers who want to ask for technical support regarding hardware, ask for support regarding software applications or ask for general information by telephone. The future process was modeled and simulated using the ARIS Collaborative suite, version 6.0. The objective of the study was twofold. The first was to draw useful conclusions about the service level that the call centre could provide (in terms of waiting time in the system’s queues), given certain hardware (call centre capacity), manning (business unit number of employees) and operational parameters (call centre up and running time, shift calendar, process work flow). The second was to assess the time needed for a customer to retrieve all the information he requested (call lead-time), given the parameters mentioned above. The net objective was to minimize the time spent by the customer in the system while providing the best possible level of service.

4.1 CRM business unit organisation

The elaborated CRM business unit model will be divided in two departments: Sales (7 employees) and Technical Support department (11 employees). The CRM designed to be up and running from 8.00 till 18.00 / Monday to Friday, but some employees would stay till 19.00 to finish with remaining customers (calls already in the system’s queue line). All employees will work 8 hours and have a 30-minute break. The shifts in Sales and Technical Support departments are depicted in Table 1. The CRM processes are planned to be supported by a call centre with a capacity of 25 telephone lines.
Table 1: The Call Centre Shift Calendar

### 4.2 The Call Centre Operation

Customers who want to contact sales, contact technical support for hardware or software issues or request information, call a 4-digit number and are automatically connected to the call centre. The number of incoming calls per time period is depicted in Table 2. If there is no line available, a busy signal is returned from the call centre, a procedure that lasts 10 seconds (constant).

If available lines exist, a welcome message is played directing the customer to one of the following options:
- Contact Sales department
- Request information
- Contact Technical Support department

Based on data from other similar CRM applications, the percentages for the above categories are respectively: 30%, 25% and 45%. The welcome message lasts for 15 seconds (constant).

If a customer wants to contact the Sales department he is forwarded to the message which describes the connection procedure and it lasts 20 seconds (constant). After the message is finished, any available employee from the Sales department answers the call. If there is no employee available, then the customer listens to the message again. It has been estimated that 95% of the customers fall into the first category while the rest 5% in the second. The system gives higher priority to the second category customers over the customers entering the queue for the first time. The time consumed in answering the call from the telephone sales section follows a normal distribution $\text{NORM}(4, 0.33)$. After the customers are served they free the line by ending their call (constant=1 sec).

If a customer wants to request information about any available product or service, he is forwarded to listen the appropriate message. This message is divided into two smaller messages (by assigning a model to a function):
- A main welcoming message which lasts $\text{NORM}(0.5, 0.05)$
- A message, which gives instructions to the caller on how connect with the Technical Support department: $(\text{NORM}(0.5, 0.05))$.

Next the customer is connected with any available employee from the Technical support department. After that the caller has two options, these being to end his call by freeing the reservation line (constant=1sec) or to contact the sales department and why not, place a pre-order. In this case the call is forwarded to the play sales message queue with no priority tag. It has been estimated that the percentage of the customers following this route is 15% of the total number of those who choose the information request option.

If a customer selects the Technical Support option, then another message is heard (15 seconds, constant) directing him either to connect with hardware or a software expert employee. Statistically, the percentages for the above categories are respectively: 65% and 35%.

The connecting to a H/W or S/W expert procedure lasts 10 seconds (constant). Either choice is forwarded to the Technical Support department where any available employee answers the call. Calls can be separated in two categories:
- Deal with hardware problem calls (85% of the total number of information request calls) which have a service time of $\text{NORM}(5, 0.5)$. After the customers are served, the calls are ended. Ending standard calls is a function which lasts one second.
- Deal with software problem calls (15% of the total number of information request calls) which have a service time of $\text{NORM}(6, 0.5)$. After the customers are served, the calls are ended. Ending special calls is a function which lasts one second.

### 4.3 The Simulation Model Run

Based on this process description an ARIS eEPC model was elaborated representing the actual problem situation. Since ARIS simulation is not a goal seeking tool but a trial and error one, the starting capacity was set to 25 available lines based on a draft market research done by the IT department of the company. The model was semantically checked, verified and validated for...
dynamically simulation. The produced eEPC is shown in Figure 2.

The call centre was assumed to be a terminating system. This concession was based on the fact that the call centre starts every day empty (no reserved lines) and idle (no employees busy). It is obvious that we could not use classical statistical methods within a simulation run because observations from one run are not independently and identically distributed. The solution to this problem is to make independent replications of the model and apply classical statistics to the values of the performance indicators obtained from the different replications. The model was simulated 1000 times for a period of one day.

After the series of runs were finished statistics for every simulation run were collected. The analysis of the averages of the simulation results gave us a clear view of the future system behavior in terms of call centre capacity, customer throughput time, customer wait time and employee utilization. These four performance indicators are further discussed in the following paragraphs.

- **Call centre capacity:** The simulation results showed that the call centre capacity presented an average of 13.18 busy lines with a highest point of 25 busy lines (system full) and a lowest point of 1 busy line.
- **Customer throughput time:** The simulation results showed us that the average stay of a customer in the system was 3 minutes and 34 seconds with a max of 9 minutes and 30 seconds and a minimum of 20 seconds.
- **Customer wait time:** The simulation results showed us that the average wait of a customer in the system’s queues was 14 seconds with a max of 3 minutes and 6 seconds and a minimum of 0 seconds. The graph depicted in Figure 3 depicts the average wait time of the customers in the system’s queues.

- **Department and employee utilisation:** The simulation results showed us that the average utilisation for the Sales staff assigned to the CRM business unit operation was 18% while the average utilisation for the Technical support staff was 23%. Furthermore, the ARIS simulation tool gave us results regarding the utilisation of all the employees assigned to the CRM unit, independently.

### 5 Conclusions

Simulation has given companies the opportunity to deal with the impacts of changing their call centres parameters off-line and without any unwanted effects on the service level they provide. This way the risk in losing customers is minimised.

In the case study presented, simulation gave management the opportunity to assess beforehand the expected results of the desired call centre implementation in terms of call centre capacity (hardware and human resources) and customer service (wait times and overall service lead times). It is within the scope of the case company and the
authors to expand the use of business process simulation in all the call centre operations after it is implemented and expand the number of indicators monitored including a series of new ones, based on balanced scorecard methodology.

A brief summary of the expected benefits of simulating the business processes is as follows:

- Enterprise knowledge and business processes will become much more transparent with an explicit, commonly understood representation and documentation.
- Intra and inter-enterprise communication will be based on easily accessible real-time information and common understanding and thereby will be significantly increased.
- Decision support for the evaluation of operational alternatives, business process re-engineering projects, exception handling and problem solving on all levels of the decision hierarchy will be based on real-time information and thereby will enhance significantly the decision quality.
- Management of change will become more effective through the ease of access to information, the ease of adaptation of the decision support base, and the visibility of impact of proposed changes prior to their implementation.

References:

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