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AN OBJECT ORIENTED SIMULATION MODEL FOR DETERMINING LABOR REQUIREMENTS AT TACO BELL

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ABSTRACT

In early 1990, Taco Bell launched a major study to develop a comprehensive and integrated Labor Management System in order to manage and optimize a payroll that exceeds $500 million per year. The core of this system is an object oriented simulation model that determines the amount and deployment of labor required in a restaurant in order to meet a given level of sales while delivering quality, service, cleanliness and value to its customers. A year has elapsed since its full implementation in company restaurants and it has realized a demonstrable bottom line impact of $7.6 million per year while increasing quality, service, cleanliness and value to the customer. The Taco Bell development and implementation teams were awarded the President's award in recognition for their contribution. This paper describes the application with particular attention to the object oriented simulation model.

Keywords: Object oriented simulation, model specifications and development, general application, manufacturing applications (food manufacturing).

1 INTRODUCTION

This study describes a major strategic thrust by Taco Bell Corporation to increase its competitiveness in the Fast Food Industry through improved labor management. Taco Bell is the largest fast food company oriented to Mexican food. It has more than 4,000 "stores" (the industry term for restaurants) located throughout the world, although predominantly located in the U.S., Canada, and Puerto Rico. Sales from company owned stores (e.g. not franchisee owned or operated) exceed $2 billion per year. Labor costs alone exceed 25% of sales, or $500 million per year. Consequently, labor costs are critical to the success of Taco Bell, not only because of the amounts involved, but because it is the largest controllable cost.

In early 1990, Taco Bell launched a major study to develop a comprehensive and integrated Labor Management System (LMS). This decision was motivated by:

- A continuing concern over labor costs;
- The potential opportunities for labor savings;
- A general consensus by management that the business had changed; and,
- An opportunity to utilize state-of-the-art labor tools.

The last two reasons proved to be the most significant. Taco Bell was one of the industry leaders in introducing the concept of "value meals". Through aggressive pricing and marketing, customer demand had changed not only in volume, but also in type of product that was ordered. In order to continue to provide a high level of service, it was clear that labor would have to be reallocated in a new manner to reflect the changing nature of the business. Past experiences did not apply directly to the new environment. Management had understood the need to have better and more timely information to manage this new business environment. To provide this, a commitment had been made to introduce IBM compatible personal computers in every Taco Bell store linked to a centralized mainframe system at the corporate headquarters. This system, together with a number of software modules to automate management paperwork, collect and transmit transactional data to the mainframes for financial control, and control aspects of store operations was referred to as TACO (Total Automation of Company Operations). It included an automated version of Taco Bell's traditional labor management system, called FAST.

The focus of FAST was to determine the minimum amount of labor required to achieve excellence in service levels. There are three predominant types of labor in a restaurant: fixed labor, variable food preparation labor, and variable customer service labor. Fixed and variable food preparation labor were determined using work measurement techniques which were then input into the system. Customer service labor was then calculated by applying an adjustment algorithm to the measured work involved in direct service of the customer. The approach was empirical and required adjustments and calibrations to its assumptions for appropriate sensitivity in response to changing customer service goals, ordering patterns, and sales volume patterns. Furthermore, calibration based on a given set of restaurants would often result in relatively unpredictable labor allocations in others. Whenever a basic assumption at the restaurants level was changed, the system had to be recalibrated, mostly with unpredictable results. This happened whenever any critical procedure was changed, or when new products were introduced. It became virtually impossible to institutionalize changes in labor allocations that represented less than one percent of labor costs. In other words, any change in procedure or of equipment that had the potential of decreasing labor cost by $5 million/year (one percent of labor cost) or less could not be translated into actual savings due to FAST's shortcomings. These shortcomings also included the system's inability to help in actual labor scheduling. This represented an unacceptable loss of opportunity in one of the most competitive of all industries.

As a result, the key labor requirements that needed to be included in Taco Bell's new LMS system were:

- Accurate labor hours required to support corporate hospitality, quality, service, and cleanliness standards;
- Restaurant specific labor management capability;
- Ability to manage Taco Bell's financial targets;
- Maximize productivity and return on labor dollar's invested;
- Provide a user friendly scheduling tool for restaurant managers;
- Provide timely feedback of actual labors used vs. allocated; and,
- Flexibility to evolve as Taco Bell evolves.

The responsibility to develop the system was given to Taco Bell's Operations Engineering Group. The group reported to a steering committee consisting of management representatives from all major divisions. The role of the steering committee was to provide input and guidance regarding labor issues and concerns, to provide access to internal resources, and to review and evaluate results. In addition, the group was allocated the resources necessary to accomplish the task, including access to required external consultants and facilities. Today, the new LMS has replaced the FAST module of TACO in each of the 2,800 company stores and is meeting or exceeding all requirements. The team that developed and implemented the system was awarded Taco Bell's Presidential Award for significant contributions to the Corporation in April, 1994.

2 OVERVIEW OF THE LABOR MANAGEMENT SYSTEM

In order to address Taco Bell's requirements for the new LMS, it was necessary to develop procedures that helped to determine the number of employees and the types of skills required to provide customer service. However, improvements in service level achieved by hiring more people can only be obtained at the expense of increased labor cost. Consequently, it was necessary to make trade-off's between labor cost and customer service level to arrive at an acceptable level of profit. Once the right amount of labor required was determined, it was necessary to schedule the labor to meet the demand. Such a schedule had to meet a number of requirements including State Laws mandating the minimum shift length for each employee including part time employees. Similarly, there are reasons to set a maximum shift length for employees. In addition, most stores have a limited number of employees on the payroll and hence a limit has to be placed on the number of employees that are scheduled for work.

In order to provide answers to the above, it was necessary to develop a fully integrated series of quantitative models, the results of one model becoming input to the next. These models included a forecasting model to project the number of customers that could be expected at the store anytime during the day, a simulation model to determine the minimum number of employees needed and their deployment in the store to provide appropriate levels of service, and optimization models to schedule employees for each shift. The remainder of this paper will describe the role of simulation modeling and analysis in answering the key question of how much labor is required and how it should be deployed in the restaurant in order to meet corporate operational standards while minimizing labor costs.

3 CATEGORIZATION OF LABOR

The type of labor used in a restaurant can be categorized into three basic types: Fixed, Food Preparation or Other Variable, and Customer Service. The categories are based on the degree in which the amount of labor required to complete a given task depends on the level of sales in the restaurant.

Fixed labor involves the labor responsible for performing tasks that are independent of sales volume. For example, most cleaning activities prior to opening or after closing of the restaurant fall into this category. For this kind of labor, the procedures are well established including when it must be performed. Consequently, standard work measurement techniques are adequate to determine the person-hours required to accomplish tasks included in this category.

Food preparation labor refers to that labor required to prepare the ingredients for the menu items that are served to the customer. Chopping lettuce or tomatoes, filling condiment containers, and filling napkin holders are examples of this category. Although the amount of labor required to perform these activities is related to the sales volume of the restaurant, it can be performed at time periods prior to or after the rush periods. As such, the amount of labor required is predicable and the scheduling of that labor is flexible. Consequently, standard work measurement techniques are also adequate to determine the person-hours required to accomplish tasks included in this category.

Customer service labor accounts for most of the labor required in a restaurant. It is labor that is used to satisfy the orders of customers. Examples of this type of labor include assembling a taco, pouring a drink, take an order, and make change. Since customer arrivals at a restaurant and what they will order are random processes, the demand for this type of labor is also random. In traditional industries, inventories are used as "shock absorbers" between the fluctuations of customer demand and the need for labor. In other words, when demand is low, labor is used to replenish inventories while when demand is high, orders are filled from the inventory accumulated during the low demand periods. This strategy has limited effectiveness in fast food operations because the amount of time that a finished product can be held before becoming unacceptable to the customer is typically measured in minutes. As a consequence, the demand for this type of labor may vary by as much as an order of magnitude from one time period to the next--for example, the half hour just before and just after the beginning of the lunch period.

4 THE NEED FOR SIMULATION

As previously mentioned, fixed labor requirements and food preparation labor requirements can be determined through traditional time study requirements. This is not the case for customer service labor requirements because of the following:

- Customer arrivals are random;
- Customers arrive at the counter and at the drive thru independently;
- What customers order is random;
- Time required to place an order, make change, and deliver the order is random;
- Time required to assemble or make the product is random;
- Completed orders must be delivered to either the drive thru or counter depending on where the order was placed;
- The amount of labor demanded is a function of the service level to be provided to the customer (e.g. the appropriate balance between labor cost and customer service needs to be assured).

Although the above is not an exhaustive list of reasons why traditional work measurement techniques are inadequate to determine customer service labor requirements, it illustrates the complexity of the problem. It also points to simulation as a solution strategy.

Simulation is not a new strategy to address the issue of determining labor requirements in a fast food environment [4]. What is new is the object oriented simulation paradigm to address these issues. This paradigm is particularly appropriate for Taco Bell because of its corporate strategy to be the value leader in the fast food business and its aggressive pursuit of new and innovative points of access (kiosks, malls, convenience stores). These strategies have made the notion of a "typical" or "standard" store configuration or menu a thing of the past. Yet, because labor costs are one of the most important determinants of whether new concepts will be financially feasible, the requirement to develop new simulation models to analyze new concepts is very strong. At the same time, the time frame to respond and provide labor cost inputs in these decisions is a matter of a few weeks. Through the development of an object oriented model, the actual coding needs associated with representing new concepts have been virtually eliminated.

5 SIMTAC: AN OBJECT-ORIENTED COMPUTER SIMULATION MODEL

Taco Bell made the decision to use an object-oriented computer simulation language to accommodate the changing needs of the business. It was assumed, and this proved to be the case, that if a basic, flexible framework could be developed initially, future modeling exercises would entail combining the basic building blocks differently. The simulation language used for this application was MODSIM from CACI, Inc. A shell of "Super Objects" called ADME provides the underlying functionality. Specific "Objects" were then developed for the particular Taco Bell applications. These "Objects" are the basis of SIMTAC (Taco Bell Simulator) which in effect has developed into a generic user-friendly fast-food restaurant simulator.

MODSIM II is described as being a modular, object oriented, strongly typed, block - structured simulation language by CACI Products Company [2]. Furthermore, an Object is described summarily as a combination of a data record, that describes the status of the Object, and a list of procedures, or Methods, that describe the behavior of the Object. Objects are instantiations of Object Types or classes of objects. As new Object Types are defined, they can inherit the functionality of existing Object Types and specialize the functionality further in the new Object Type. Objects can also be polymorphous as objects with common ancestry and therefore common Methods can implement these inherited Methods differently.

The SIMTAC implementation makes strong use of the inheritance capabilities as depicted graphically in Figure 1.

Conceptual Representation of SIMTAC and its Relationship to ADME, SIMGRAPHICS, and MODSIM

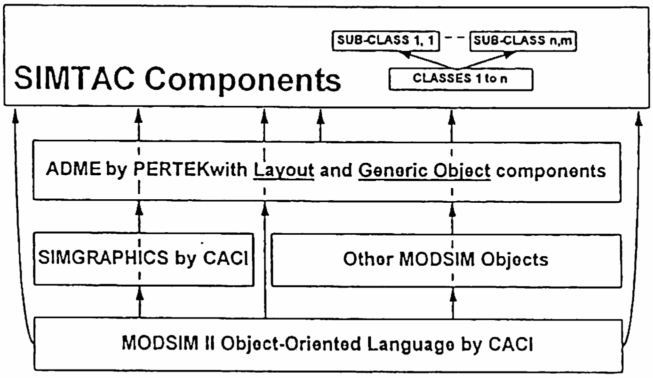

Figure 1: SIMTAC Inheritance Capabilities

The arrows show the inheritance from the lower level of the MODSIM II language all the way to the SIMTAC implementation. All Objects are implemented using MODSIM II which is provided with a library of base objects that can be used at higher levels for defining identical or modified Object Types. SIMGRAPHICS [3] consists of a number of Graphical Objects implemented with MODSIM. ADME [1], which was developed by Pertek Industries, defines a number of flexible generic objects which inherit behaviors from SIMGRAPHICS and MODSIM II Objects types. Finally, the SIMTAC level Object Types inherit functionality predominantly from ADME and all lower levels. Within SIMTAC, several levels of Objects can exist which inherit functionality of Object Types within SIMTAC as well as levels below it.

To illustrate this with a specific example, consider two Object Types such as " Worker" and " Customer" Object Types. Both Workers and Customers are a sub-class of the Human class of Object Types within SIMTAC. The class of Humans inherits the Method Describe from ADME, and the capability of being rendered graphically from SIMGRAPHICS. Figure 2 illustrates the class hierarchy for ADME and the MODSIM and SIMGRAPHICS classes on which it depends.

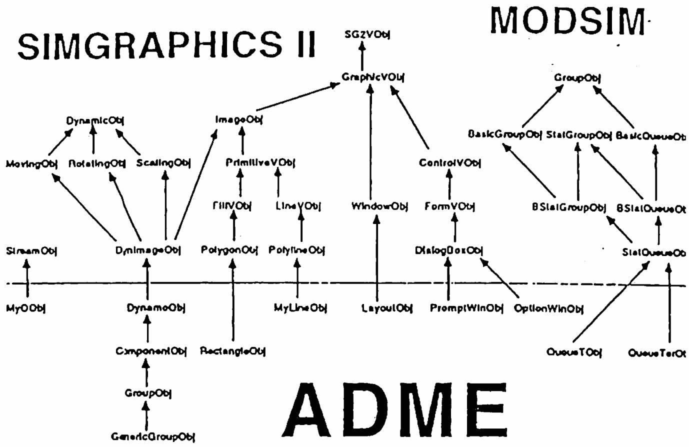

Figure 2: SIMTAC Class Hierarchies

Figures 3 and 4 show the different menus generated when prompting a Worker and Customer, showing common choices as well as those specifying each object type. The "Scale" selection will invoke a method inherited from SIMGRAPHICS objects, the "Show References" selection will invoke a method implemented at the ADME level, the "Describe" selection will invoke a method that shows polymorphism (as it behaves differently for workers and customers), and the "Add/Edit Task" selection will invoke a method only available to the Worker Object Type.

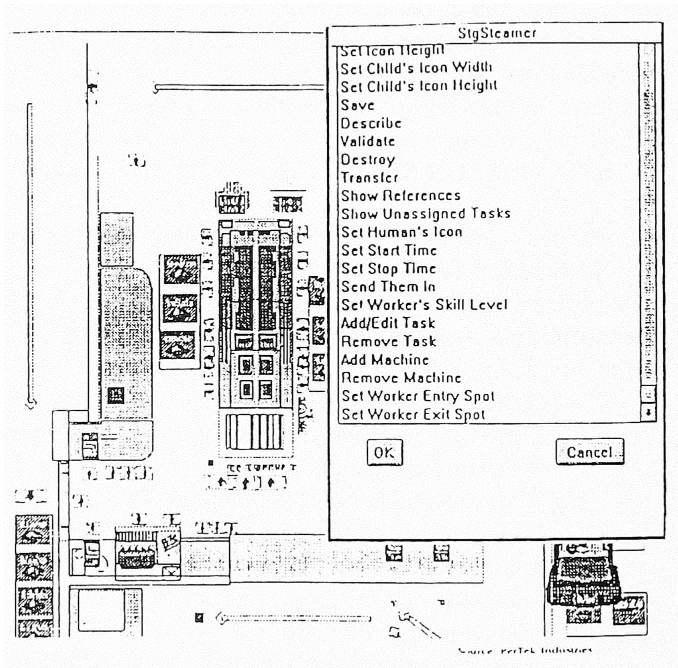

Figure 3: Result of "prompting" a "Worker Object"

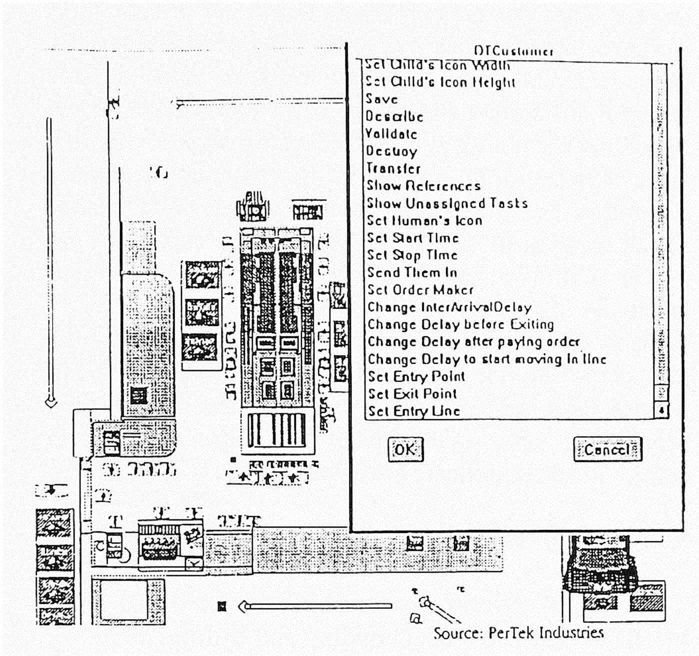

Figure 4: Result of "prompting" a "Customer Object"

The approach described above has some very positive implications for the developer. Independently of the initial cost of developing a first model of a given problem, new models can be derived at a relatively low cost because of the high re-usability of available modules.

At the highest levels, the existing object types can be enhanced or differentiated further in their functionality. Currently, the SIMTAC model is limited to one type of "Customer" which enters the system, waits in line to place orders, places orders, pays, waits in line to receive the order, receives the order, and leaves. SIMTAC only models the production areas so walk-up customers are not modeled as going to tables, and behave identically to customers that take out their food. If in the near future it were necessary to model the "eat-in" customer, a new Object Type could be derived from the existing Customer Object Type. The new "eat-in" customer would have new Methods such as "Walk to the table", "Eat at the table", and "Leave the table" while selectively keeping all the pertinent elements of the Customer Object Type.

At lower levels, any change made would affect all descendant object types, thus multiplying the productivity of the developer. If for some reason, it were necessary to neutralize the effects of changes in a subset of the descendants, this could be done selectively at the appropriate level.

Object-oriented modeling is similar to "Branch-and-Bound" problem solving in that a feasible "Branch" can be pursued as a solution to a modeling problem until it is necessary to return to an appropriate level of ascendancy to explore new "Branches". Beyond objective and measurable modeling productivity, the development experience for the SIMTAC system has shown that the object oriented modeling paradigm places little if any restrictions on creativity while yielding superior system models to the end user. In the next section, SIMTAC'S capabilities, from the point of view of the user, are summarized in more detail.

5.1 Model Functionality from a User's Perspective

Restaurant simulation models based on SIMTAC can be built or modified without any programming. Actions are performed by selecting from pull-down menus, and data is input at prompts provided by selections from the pull-down menus. Objects required for a simulation modeling study can be incorporated and related to each other as required.

As described above, "Objects" are defined by the functions or the "Methods" that they are able to perform. Some of the "Methods" are evident to the user in pull-down menu selections, but the vast majority are not. For example "Human Objects" will move with a "Move Method" to the location of the next action that they need to execute such as, "Exit Restaurant Method" without intervention from the user. The location and time of the action however, is defined by the user as a "Set Exit Spot Method" and "Set Exit Time Method" in a pull-down menu.

All objects possess certain common methods that are executed in an identical fashion by each and every one of them. Examples of these are the "Zoom to", "Scale", "Rotate", "Save to File", "Show References" and "Load to Layout" methods. Certain objects possess some common methods with executions that are specific to the type of object. An example of this is the "Describe" method which in a "Worker" object lists entry and exit times, efficiency and tasks assigned; while for a "Food" object the "Describe" method will list ingredients, recipe, shelf life and price. As objects become more specific they are assigned methods specific to the functionality of the object. For example, a "Cash Register" object possesses a "Set Order Delay" method which is not available to any other object.

5.1.1 Types of Objects

SIMTAC's basic objects were classified as static, dynamic, and group objects.

5.1.2 Static Objects

Static objects include equipment, logical, human holding, and inanimate objects. Equipment objects describe where tasks are performed. Each has a physical equivalent in the restaurant. Examples of these are food-assembly lines, fryers, drink makers, grills, toasters, generic workstations, drive-through windows and food holding bins. "Tasks", such as assembly of products or placing fries in a frier, require the presence of "Workers", while "Processes", such as cooking fries or burgers, do not. Monitors and Cash Registers are special cases of equipment objects as they play a significant role in defining the logical relationships between different equipment objects and the flow of customers, orders and food items.

Logical objects predominantly define logical relationships between customers, orders, food items and workers. Some logical objects define certain tasks that need to be executed to complete customer orders. These objects do not have a physical equivalent in the restaurant. Examples of these are the "Consolidator" and "Router" objects. The "Consolidator" object defines how orders are assembled from finished products into bags and trays, the "Router" object defines routing priorities when more than one equipment is available for transforming a given product.

Human holding objects define where humans stand while they perform tasks or wait to perform tasks. One "Human" can stand at each "Spot" object while between 1 and 20 "Humans" can stand at each "Line" object.

Inanimate Objects represent those that are physically present in the restaurant and act as an obstacle to the circulation of "Humans". Examples of inanimate objects are walls and counters. A special inanimate object is the CAD object which is used for importing DXF-formatted two-dimensional layout plans.

5.1.3 Dynamic Objects

This category of objects includes food objects, human objects, and food grouping objects. Food objects represent the individual products that are manufactured or assembled at the restaurant. Drawing an equivalence to manufacturing, a bill of materials becomes a list of ingredients, a process plan is a recipe, and storage is a holder. The first ingredient of a food object can also be another food object which is equivalent to a sub-assembly in manufacturing. Assembly and process delays are typically defined in the food object.

Human Objects are the customers and workers. Customers perform a defined list of tasks: arrive, order, pay, get food and leave and the user needs to define where they are performed. Workers perform tasks at locations defined by equipment objects and some logical objects. The user defines which tasks and priorities the worker will perform as well as the inter-arrival delays for customers and efficiencies for workers. The "human Objects" are designed to follow paths that are defined by a "Pathmaker" function in SIMTAC in such a way that static objects are avoided. This obstacle avoidance capability is automatically optimized with every change in the location of any static object. This capability has proven useful in the analysis of different restaurant layout alternatives.

Food Grouping Objects are used to combine several food items into one entity to facilitate handling. Some of these objects, spatulas and fry baskets, are used in food production; while others, bags and trays, are used to deliver finished products to customers.

5.1.4 Group Objects

These objects are used to combine dynamic and static objects to facilitate model building and editing.

6 SIGNIFICANCE OF WORK

The significance of this study is both tactical and strategic. The SIMTAC model is the heart of an integrated Labor Management System which allows the productivity of labor and the return on dollars invested in labor to be maximized. The documented labor savings are one hour per day in each Taco Bell store. In a system with more than 4,000 stores open an average of 363 days a year, the realized bottom line impact is approximately \$2.7 million per year per 1000 stores (assuming an hourly total labor cost of \$7.50). However, there are other perhaps even more significant benefits. As a result of this study, there is now an entirely new, flexible, and adaptable methodology in place to determine how much labor is actually needed at each store and how that labor should be deployed in the store. Before, with the FAST system, the manager was told how many hours of labor were allocated to the store. It was then his or her responsibility to decide how to most effectively deploy this labor. This resulted in variability in the level of service, hospitality, quality, and cleanliness at different stores. Such variability is one of the most significant sources of customer dissatisfaction in the fast food industry. The elimination of variability will increase customer satisfaction which will lead to a greater frequency of visitation and, hence, higher sales.

The "driver" of the new LMS is the level of customer service that management wishes to provide. Given a specified level of service, typically stated as average customer waiting time, the LMS system can project sales, use SIMTAC to determine staffing levels, and use optimization to schedule crews. This information is then translated into labor cost using prevailing labor rates. This capability provides management with the capability to manage to Taco Bell's financial targets. Effective total management is achieved when this information is balanced with other marketing and strategic studies which indicate the impact on short and long term customer behavior as a result of changes in service level.

The new LMS is a planning and scheduling system as well as a control system. It provides store management with recommendations regarding the amount of labor it should use as well as specific inputs on how it should be scheduled and deployed. It is the store manager's responsibility to translate these recommendations into action. It is higher management's responsibilities to insure that store managers are executing their responsibilities as expected. The new LMS system provides management with a timely feedback on how many labor hours were used in a particular restaurant (obtained from payroll information) and the amount of labor that was recommended (obtained from the LMS). This information is used not only to monitor store manager's performance, but also as a control on the performance of the new LMS system. All problems that are perceived with the new LMS system are documented and investigated. As such, the LMS system is in a state of continuous improvement to better help Taco Bell manage its labor resources.

7 CONCLUSION

This study has taken place over a period of four years. It now has been fully deployed as an integrated system in the entire Taco Bell system of company owned stores. Almost a year has elapsed since initial implementation, during which time the performance of the system was scrutinized and evaluated by virtually everybody, from store manager to vice-presidents of operations and the CEO. Even though the developers and implementers of the system received Taco Bell's highest recognition for their contribution, it must be remembered that a system like this is a living entity. Everybody in the corporation has a stake in it and has suggestions, criticisms, praises, and questions. All of these must continually be addressed and appropriate responses made. In doing so, the system is continually improved and increases its contributions to Taco Bell. What is emerging is the realization that there is another strategy for success, that of information and technology, which can take its place next to the traditional strategies of finance, marketing, and operations to achieve success in this most competitive of industries.

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AUTHOR BIOGRAPHIES

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WILLIAM SWART is Dean of New Jersey Institute of Technology's Newark College of Engineering. He is a former Vice President of Burger King Corporation, where he received the 1981 Franz Edelman award for the practice of Management Science and the Restaurant and Institutions Magazine Honorable mention award for Food Facilities Design. Together with Mark Godward, he received the 1994 Institute of Industrial Engineering Operations Research Division Award for Outstanding Application of Operations Research Techniques Producing Significant Results. He serves as a strategic consultant to Taco Bell Corporation.