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BUSINESS PROCESS REENGINEERING AT THE HOSPITALS: A CASE STUDY AT SINGAPORE HOSPITAL

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ABSTRACT

As health care costs increase, there is a need for healthcare service providers to look for ways to contain costs and to achieve a higher efficiency at their operating facilities without sacrificing quality. This paper studies a case in employing business process reengineering techniques on one aspect of a health care service – surgical work. The system is simulated focusing on the processes that contribute to the effective functioning of an operating theatre.

INTRODUCTION

Business process reengineering (BPR) has become increasingly important in recent years. Customers now have the choice of different product and service providers, to provide them with the same core product or service that they want. Over the last fifteen years, companies have been forced to reengineering their business processes to stay competitive because customers are demanding better products and services. Improving and redesigning business processes is paramount for businesses to stay competitive.

With the escalating health care costs, healthcare service providers in Singapore are also continuously seeking ways to stay competitive and provide quality service to the customers. Little research has been done on the employment of BPR in healthcare systems. Healthcare industry has traditionally emphasized on breakthroughs in operating procedures and technology in the bid to stay competitive. Healthcare service providers are beginning to understand that BPR initiatives could be a better solution to achieving competitive advantage.

The operating theatre suite is a critically important segment of any healthcare organization that delivers surgical care to patients. It can consume multitudes of resources, but at the same time can generate significant revenue if managed properly. The conflict between the national goal of healthcare and the high cost of surgical operations is a powerful incentive to improve the quality of management of the surgical suite. For this reason, many hospitals are reengineering their operating theatre processes in an effort to establish, restore or boost profitability while retaining quality (Harris and Zitzmann 2013; Gabel et al. 2014). Reengineering techniques enable healthcare service providers to take a careful look at the processes involved within the organization, identifying redundancy and inefficiency that can be removed from the system. This research employs the concept of BPR to improve the efficiency and effectiveness of certain processes involved in surgical operations.

This paper intends to explore the possibilities of cost containment/reduction in a particular aspect of the healthcare industry with the application of BPR. A simulation model has been formulated to reduce any inefficiencies or bottlenecks inherent in the system under study. The scope of this research is limited to an operating theatre suite within a hospital.

LITERATURE REVIEW

The aggregate per capita healthcare expenditure in Singapore has risen consistently for the last three decades from about S$150 in the 1960s to S$800 in the 2014 (Tan and Chew 2014). The healthcare industry in Singapore, like its global counterparts, has been facing tremendous pressures since the turn of the last century. The challenges faced by the industry in the near future are as follows.

The accelerated population ageing will have serious implications to the provisions of health care for the elderly population who will occupy most of the hospital beds with a low turnover rate. Moreover, the entry of more private- sector hospitals and medical service will lead to more attractive opportunities to health care professionals (Zhang 2012).

There is a lack of health care professionals in Singapore. The local doctor-to -patient ratio was 140 doctors for every 100,000 of the population for the year 2000. According to OECD data, the average ratios for the decade of the '90s for Australia and New Zealand were 240 and 218 respectively (Wee 2013).

Business Process Reengineering in Healthcare

Managers use process reengineering methods to discover the best processes for performing work, and that these processes be reengineered to optimize productivity (Weicher et al. 2000). Hammer and Champy (2011) state that BPR refers to the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality and speed. Business processes are sequences and combinations of activities that deliver value to a customer (Coulson-Thomas 2010). A core business process usually creates value by the capabilities it gives the company for competitiveness. A limited number of such core business processes can be identified in any company, and enhancing those processes can lead to business improvement.

Over the last few years, the reengineering concept has evolved from a "radical change" to account for the contextual realism (Caron et al. 2010, Earl 2011). Davenport and Short (2011) prescribe a five-step approach to BPR. They argue that process reengineering requires taking a broader view of both IT and business activity, and of the relationships between them. The rhetoric of BPR also encourages fundamental step, or frame-breaking change (Coulson-Thomas 2010). BPR is increasingly recognized as a form of organizational change characterized by strategic transformation of interrelated organizational sub-systems producing varied levels of impact. This organizational change perspective recognizes that business process reengineering is not a monolithic concept but rather a continuum of approaches to process change (Kettinger et al. 2010). The faster the speed of change the more difficult and stressful it is to manage (Edwards and Walton 2007).

With 80 percent of the expenses tied to patient care activities, hospitals and healthcare systems can garner substantial savings and improve clinical practices by better managing their labor, supplies, equipment, and facilities. The benefits of reinventing hospitals hold the tangible and realistic promise of radically reducing cost while dramatically increasing the quality of care provided (Harmon 2013).

A case study at Karolinska Hospital in Sweden by Jacob (2013), and Hout and Stalk (2014) reveals that rising costs and a weakened economy in 1990s were forcing the government to reassess and reduce health care expenditures. Karolinska followed Boston Consulting Group's (BCG) Time-Based Management methods to reengineer the way work was done. BCG reorganized work at the hospital around patient flow by creating a new position of "nurse coordinator" in most departments. By redesigning operating procedures and staffing patterns, Karolinska was able to cut the time required for preoperative testing from months to days, close 2 of 15 operating rooms and still increase the number of operations per day by 30 percent.

Operating theatre management often involves human resources, information systems, finance, physical plant design and utilization, capital equipment, clinical quality and efficiency and regulatory (Merriam-Webster 2014). Furthermore, surgical cases are conventionally classified into elective and emergency. An elective case is one whereby the patient can wait at least three days without sustaining morbidity or mortality. A surgical group comprises of several surgeons who share allocated operating theatre time. The term *block time* is the time allocated to each surgical group into which only the surgeons belonging to that surgical group can schedule their patients.

Managing operating theatre suites is a difficult task, because individual theatres and the entire suite are highly complex and tense environments. Many personnel working in the suite are not under the direct control of the operating theatre manager. The operating theatre schedule sets the stage for the daily flow of patients and staff. Once the day starts, however, deviations from this schedule are frequent and expected. Emergency cases must be accommodated, cases may be longer or (rarely) shorter than scheduled, patients may be late or fail to arrive at all, and personnel may call in sick or become ill during the course of the day (Gabel et al. 2012).

Modern operating theatre management requires an information system that includes an effective scheduling system. Such a system has two basic but critical functions: performing the actual scheduling of cases, which involves finding out the time available on the schedule, whether that time occurs in a surgeon's specific block time, and to facilitate intelligent management of resources. It must provide data on how resources are being used in relation to their availability (Harris et al. 1998). Block scheduling assigns a surgeon (or a surgical group) a block of time that is exclusively for his cases.

The anaesthesia service is often a separate department; in some hospitals it is a division under surgery department. In contrast with surgical sub - specialties, anaesthetists specializing in specific clinical areas such as pediatric anaesthesia, obstetric anaesthesia and cardiac anaesthesia are not typically organized into distinct departments. The anaesthesia department must be organized in such a way as to ensure availability of a sufficient number of anaesthesia providers for elective and emergency cases, which requires 24-hour-a-day coverage (Gabel et al. 2011).

Simulation in the Health Care Industry

The health care industry is a dynamic system with complex interactions, in which the simulation technique would play an indirect but vital role to achieve the optimal result (Zhang 2010). Kelton et al. (2008) state that the real power of the simulation technique is fully realized when it is used to study a complex system. Numerous healthcare service providers such as D. R. Hospital in North Carolina, and St John Hospital in Detroit, U.S.A. have successfully employed the simulation technique to help them in understanding their processes and to optimize them (ProModel Corporation 2009).

CASE STUDY

The Department of Surgery at the Singapore Hospital oversees the operations of the surgical theatres. The main operating theatre complex at Block 3 of the hospital grounds is where surgical operations of different specialties take place. The local demand for surgery services has increased over the last two decades. The capacity of the operating theatres at the complex has reached high levels of utilization, and action is necessary to ensure that the department is able to cope with increasing patient load. Due to the increasing demand by patients on the services provided by this operating theatre complex and the acute shortage of manpower in the local health care industry, the Department of Surgery has to employ reengineering practices to achieve more efficient and effective utilization with its existing resources.

There are a total of 21 operating theatres at the main OT complex at Block 3 of the hospital. In the year 2012, the number of surgical operations conducted at the hospital was 59,377, of which about 45% were outpatient (day) surgeries. The daily average was 162. Out of the 21 theatres, 19 are allocated for elective surgery and operate 8 hours a day (from 8:30 to 17:30), and the remaining 2 are employed as emergency operating theatres and operate 24 hours a day. Historical data was extracted from the hospital's scheduling database for the period January to September 2001. The data includes the percentage utilization of all the operating theatres, and the surgeons' log of all the surgical operations conducted within the same period.

Every day, each operating theatre is reserved for a specific clinical discipline to carry out surgical operations. Some of the operating theatres are exclusively reserved for a particular discipline, whereas others may be used by different disciplines for each day of the week.

MODELING OF THE OPERATING THEATRE COMPLEX

MedModel is a simulation-based powerful software tool for evaluating, planning or re-designing hospitals and other healthcare systems. It provides a basis for the comprehensive evaluation of large and complex health care systems. MedModel is also equipped with an impressive collection of pre-programmed constructs. Before a model for the operating theatre complex can be developed, a flow chart of the operating theatre process is provided in Figure 1 to illustrate the entities, resources and locations involved. Figure 2 shows the layout of the completed simulation model. The proportion of elective surgical operations for each clinical discipline varies greatly.

To keep simulation as simple as possible, this model deals with only 8 operating theatres, each

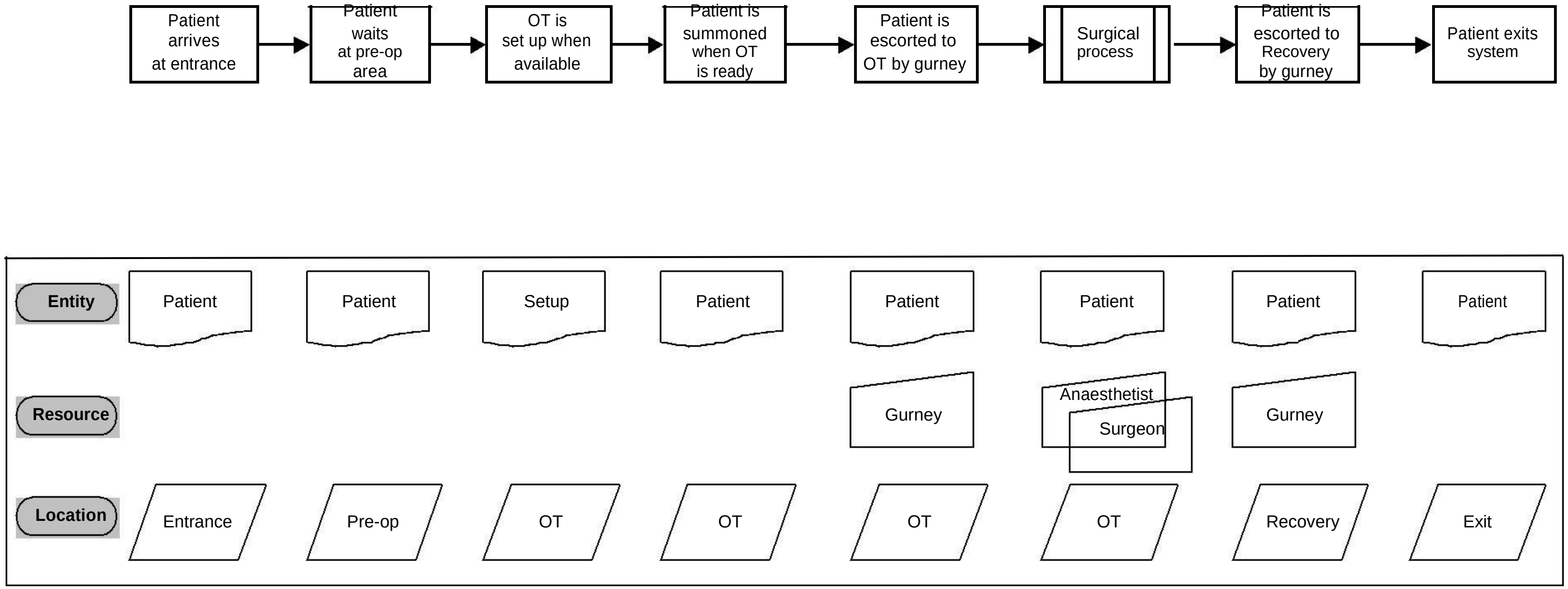

Figure 1: Flow Chart of the Operating Theatre Process

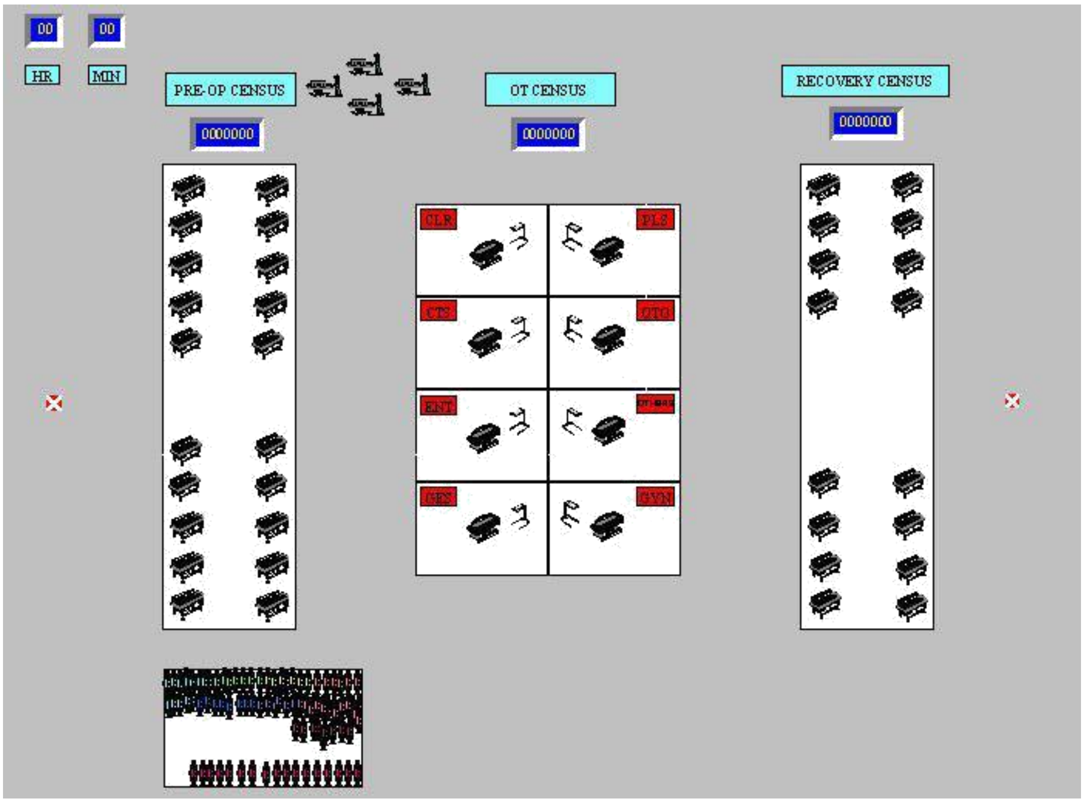

Figure 2: Layout of Completed Simulation Model

Table 1: Patient Types and Distribution

Patient Type	Clinical code	Percentage(%)	Surgery required
1	CLR	12	Colorectal surgery
2	CTS	6	Cardiothoracic surgery
3	ENT	9	Ear, nose and Throat surgery
4	GES	26	General surgery
5	GYN	11	Obstetrics and gynaecology
6	OTHERS	9	Other surgery
7	OTO	22	Orthopaedic surgery
8	PLS	5	Plastic surgery

reserved for a different category of surgery. As such, the number of entities and resources used in this model will be scaled down from the real-life numbers obtained. There are 2 entities in this simulation model, namely *Patient* and *Setup*. In accordance with the 8 categories of surgical cases, the patient is classified into 8 different types using the attribute *aPt_ Type* and the user-defined distribution *dPt_Type*. The patient types and distribution are listed in Table 1. It should be noted that the number convention assigned to each type of surgery (such as "1" for CLR, "2" for CTS) is the same throughout the simulation.

Before the entity *Patient* is routed into the operating theatre, the entity *Setup* is first routed into the operating theatre, together with the resource *Anaesthetist*. This is to model the pre-operation procedures required to get the operating theatre ready for surgery on the incoming patient. These pre-operation procedures take 0.5 hours or 30 minutes. As such, there is no need to classify this entity into 8 different types as for the entity *Patient*. The entity *Setup* stays in the operating theatre for 30 minutes with the resource *Anaesthetist* before the entity *Patient* is summoned into the operating theatre to join them.

Locations represent fixed places in the system where entities are routed for processing. This model has 5 locations. Moreover, entrance is the point of entry for the entity *Patient*. The number of entries (or the number of arrivals of this entity) at this location is determined by an arrival cycle. The entity *Patient* is next routed to the pre-operation area (Pre-op), where it waits for 30 minutes before it is called to the next location on the process logic, which can be any of the 8 operating theatres. Should this next location be full, the entity remains at this location until the next location becomes available. The location *Pre-op* is a multi-capacity location; its capacity is 20 patients. The location *Recovery* has a capacity of 16. The model assumes that each patient spends 0.25 hours or 15 minutes in the recovery area.

A resource is a person or piece of equipment used for one or more of the following functions: treating or moving patients, assisting in performing tasks for entities at locations, performing maintenance on or for locations or other resources. In this model, there are 10 groups of resources. Of the ten, eight types represent 8 groups of surgeons from the eight different surgical specialties, *Surgeon1* to *Surgeon8*. The other two groups are *Anaesthetist* and *Gurney*.

Reengineering the Operating Theatre Complex

It has been noted that the level of utilization for the operating theatres at the complex is rather high. The next step is to improve the efficiency of the system, such that it can achieve greater output with utilization of the same amount of resources.

Currently, the elective operating theatres at the hospital operate eight hours a day, from 08:30 to 17:30. Despite this, surgical operations often end beyond 17:30, due to delays occurring in the individual operating theatre throughout the course of the day. Sometimes it could simply be due to the complexity of the surgery.

In an effort to improve the efficiency of the complex, operating theatre personnel have suggested the possibility of implementing a shift system in place of the current system. By making changes to the variables used, the operating theatre process is reengineered to incorporate the shift system and investigated using the simulation model developed above. In simulating the shift system, 2 changes are made to the original model.

- Arrival Cycle: Instead of patients arriving between 08:00 and 18:00 over a 24-hour period starting at 08:00, patients now arrive between 08:00 and 04:00 over the same period and with the same distribution. This represents 2 shifts with 10 hours to each shift.
- Number of resource units: Since the new 2-shift model utilizes the same amount of resources, as before, the pool of resources has to be shared between the two shifts. This results in less number of surgeons and anaesthetists on duty at any one time. This is incorporated in the new model by halving the number of resource units available.

In implementing a shift system, the system might not have sufficient resources to cope with the increased workload. In an extreme scenario, twice the amount of resources is needed to maintain the level of effectiveness of the system. This is simulated in a third model, by maintaining the number of resource units with the implementation of the shift system.

When two specialties are allocated the use of an operating theatre on the same day, one uses the theatre in the morning and the other in the afternoon. In the extreme scenario, declassifying all the operating theatres means that no surgical specialty has the exclusive right to any operating theatre. This facilitates the allocation of surgical on a first-come-first-served basis. To model the new system with no classification of operating theatres, the attribute *aPt_Room* and its assignments are removed from the model. Removing it would allow the entity *Patient* to go to any operating theatre location regardless of the patient type.

RESULTS AND DISCUSSION

The simulation model was run for 168 hours (7 days), with a warm- up period of 48 hours, with 20 replications. Table 2 gives a summary of the utilization of the locations. It can be seen that high utilization occurs at OT (OTO), which is the OT reserved for orthopaedic surgery. The pre-operation area is also highly utilized due to the number of patients waiting for orthopaedic surgery. This creates a bottleneck at the pre-operating area, and leads to patient arrival failures. This important issue suggested the possibilities for reengineering.

Figure 3 shows the utilization of resources for the simulation. As the crucial resources in our model are the surgeons and the anaesthetists, it was assumed that gurneys are always available when needed in developing the model. It can be seen that of all the resources available, the group of anaesthetists within the system is the most highly utilized at 18.25%. On top of this, anaesthetists also have teaching and research responsibilities. Thus, the actual utilization hours for the resources used in this simulation model is higher than reflected in Figure 3.

The three suggested models for reengineering were similarly run for 168 hours with 20 replications. The location utilization of the reengineered models is compared with the original model in Table 3. We will refer to the shift system model as Model 1, the shift system with increased staff model as Model 2 and the declassified operating theatres model as Model 3. It should be noted that for Model 3, the operating theatres have been renamed to OT1- OT8. The resource utilization of the reengineered models is compared with the original model in Figure 4. Table 4 summarizes the relevant entity states and efficiency for the 4 models.

Based on the results of simulation, the most efficient model is Model 3, which declassifies the operating theatres and allows any surgical specialty to conduct surgical operations in any operating theatre. This method reduces the utilization of the pre-operating area from over 90% to 69%, which indicates alleviation of the bottleneck seen previously at this location. The efficiency of this proposed system is found to be 64.8%, an improvement from 45.6% of the current model.

CONCLUSIONS

An in-depth study of the operating complex at the Singapore Hospital has been conducted with the use of simulation software, MedModel. The utilization of the operating theatre complex and its two main resources, the surgeons and anaesthetists, were analyzed in detail. The software modeled the complex operating theatre system accurately and with confidence in results. Due to the comprehensive nature of the simulation software tool, assumptions and shortcuts that have routinely characterized health care and hospital simulations were no longer necessary. The software has allowed modeling the gamut of operating theatre activities quickly and efficiently, from patient admission to disposition.

Several possibilities for process reengineering were proposed to reduce the utilization of the operating theatres within the complex. These possibilities were implemented on the simulation model. The results of the simulation have indicated that operating theatres servicing certain surgical specialties within the operating theatre complex are highly utilized. The surgeons belonging to those specialties are also in high demand. The results also indicate that the anaesthetists serving the complex are highly utilized, possibly due to their anaesthetic responsibilities outside the operation theatre and the pre-operative and post-operative work they conduct for surgical cases.

Thus, in order to maximize the productivity of the operating theatre complex without increasing the workload of the surgeons and anaesthetists, the management needs to look for a way to redesign the operating theatre process. It is also recommended that data collection with regards to operating theatre utilization be reviewed periodically for accuracy and transparency in the data collection process. This is crucial in order to obtain a true representation of the utilization states of the operating theatres, and in turn an accurate productivity index can be derived.

Table 2: Location Utilization

Location	Capacity	Total Entries	Avg minutes per entry	Utilization (%)
Entrance	1	45.65	80.69	33.26
Pre Op	20	63.65	3012.29	92.43
Recovery	16	50.85	31.49	0.99
Exit	1	50.85	0.00	0.00
OT (CLR)	1	5.20	199.75	10.24
OT (CTS)	1	2.75	286.62	8.18
OT (ENT)	1	4.90	286.56	14.26
OT (GES)	1	18.45	379.87	69.09
OT (GYN)	1	6.10	194.34	11.58
OT (Others)	1	6.60	1478.34	88.87
OT (OTO)	1	6.10	1790.40	100.00
OT (PLS)	1	2.25	350.80	8.56

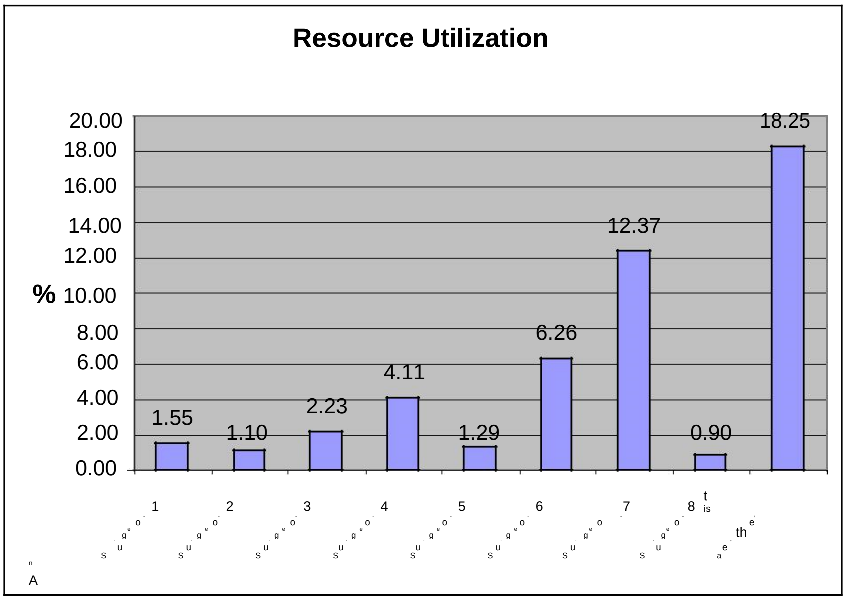

Figure 3: Resource Utilization

Table 3: Location Utilization – Comparing the 4 Models

Location	Utilization (%)			
	Original Model	Model 1	Model 2	Model 3
Entrance	33.26	59.16	55.76	23.00
Pre Op	92.43	96.40	96.06	69.36
Recovery	0.99	1.05	0.97	1.90
Exit	0.00	0.00	0.00	0.00
OT(CLR)/OT1	10.24	9.23	10.29	92.44
OT(CTS)/OT2	8.18	10.34	9.18	91.13
OT(ENT)/OT3	14.26	13.05	15.85	92.49
OT(GES)/OT4	69.09	78.37	69.21	93.94
OT(GYN)/OT5	11.58	10.46	9.42	92.77
OT(Others)/OT6	88.87	91.04	83.37	94.27
OT(OTO)/OT7	100.00	100.00	100.00	94.15
OT(PLS)/OT8	8.56	7.34	7.45	94.12

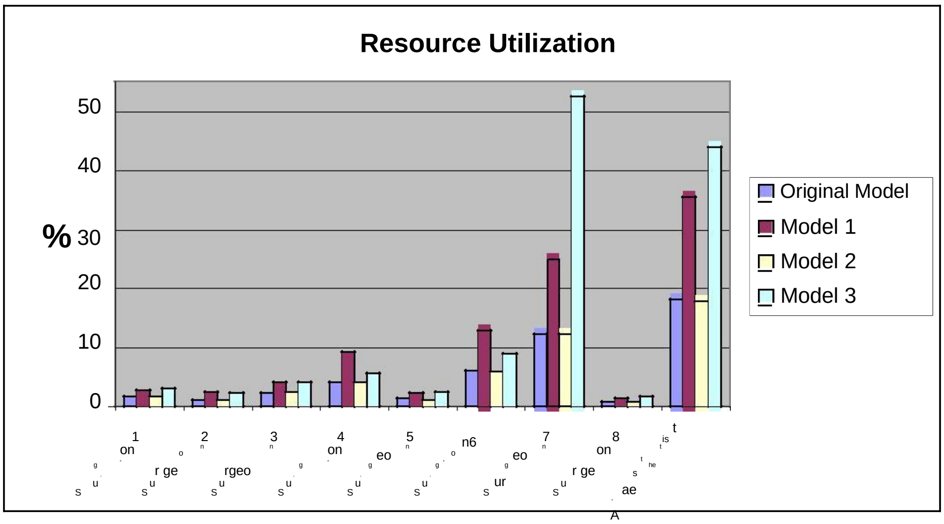

Figure 4: Resource Utilization – Comparing the 4 Models

Table 4: Entity States and Efficiency – Comparing the 4 Models

Entity	Original Model	Model 1	Model 2	Model 3
Average time in system (mins)	1237.80	1207.46	1291.56	1314.72
Average time in blocked state (mins)	874.34	852.37	920.46	864.70
Total number of exits	99.40	100.10	96.55	186.95
Total remaining in system	16.90	17.50	17.30	1.90
Total number of failed arrivals	138.95	141.85	141.90	102.5
Efficiency (%)	**45.6**	**45.3**	**44.5**	**64.8**

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