ALLOCATION OF EMPLOYEES TO COMMITTEES IN UNCERTAIN ENVIRONMENTS WITHIN THE GENERAL INSPECTOR'S OFFICE

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ALLOCATION OF EMPLOYEES TO COMMITTEES IN UNCERTAIN ENVIRONMENTS WITHIN THE GENERAL INSPECTOR'S OFFICE

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ABSTRACT

ALLOCATION OF EMPLOYEES TO COMMITTEES IN UNCERTAIN ENVIRONMENTS WITHIN THE GENERAL INSPECTOR'S OFFICE

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The General Inspector's Office is responsible for handling corruption cases in Iraq. It does this by creating teams of experts to look into and make recommendations on each case that arrives. When the tasks arrive and what level of complexity are not known in advance. Currently, no automated system is in place for the creation of teams and allocation to cases. Instead, this is done by the manager without consider the experience levels of the employees. In this research, we show, through simulation, how several alternative work practices, replacing the manager's decision making, can lead to different Key Performance Indicators (KPI). The results show that we achieve the best solution for the number of completed cases in terms of using a flexible allocation of staff and 'last case arrival, first to process' (LIFO). In particular, for the number of completed cases we achieved in theory a 98% rate, compared to an actual 57% rate for the year of 2016.

Keywords: Corruption, Simulation, Dispatch rules

ÖZ

GENEL MÜFETTİŞ DAİRESİNİN BELİRGİN OLMAYAN ÇEVRELERDE ALT KURULLARA ÇALIŞAN ATAMASI

AL-JANABI, Ammar

Bilgi Teknolojileri Anabilim Dalı

Tez Yöneticisi: Yrd. Doç. Dr. James LITTLE

Ekim 2017, 35 sayfa

Irak'ta yozlaşma dosyalarına, genel müfettiş dairesi bakmakla yükümlüdür. Daire, bu görevini uzmanlardan oluşturduğu ekiplerle yürütür. Bu ekipler, gelen her dosyaya bakar ve öneride bulunurlar. İşin ne zaman geleceği ve ne karmaşıklıkta olacağı önceden bilinmez. Halihazırda, dosyalara atanacak ekipler ve bunların oluşturulmasında bir otomosyon bulunmamaktadır. Bunun yerine yöneticiler, çalışanların deneyimlerini göz önünde bulundurmadan atamalar yapmaktadırlar. Bu araştırmada, alternatif uygulamaların, yöneticinin kararının yerine nasıl geçebileceğini ve bunun farklı anahtar performans göstergelerine gidebileceğini simülasyonla gösterdik. Sonuçlar göstermektedir ki biten dosyalar sayısında en iyi çözüme ulaştık; buna, çalışanların esnek atanması ve son gelen ilk işleme konur şartlarıyla ulaşılmıştır. Özellikle bu başarıya, 2016 yılında gerçekte bakılan dosya oranı %57'yken buna kıyasla bizim teoride, %98'e ulaşmamız gösterilebilir.

Anahtar sözcükler: Yozlaşma, simülasyon, öncelik sıralama kuralı

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LIST OF ABBREVIATIONS

GIO	General Inspector’s Office
SC	Simple Cases
MC	Medium Cases
CC	Complex Cases
KPI	Key Performance Indicator
NCC	Number of Completed Cases
AWT	Average Waiting Time
MQL	Maximum Queue Length
UOE	Utilization of Employees

CHAPTER 1

INTRODUCTION

1.1 Corruption Handling in Iraq

The current level of corruption in Iraq is one of the main reasons for the delay in development of the country's infrastructure. The General Inspector’s Offices (GIO) were set up across the Iraqi ministries through a decision by Paul Bremer [1], who was the Administrator of the Coalition Provisional Authority at 2003-2004 under Law No. 57 in 2004.

The Offices address cases of corruption through the formation of investigation committees. The works of these committees is to investigate cases such as bribery, embezzlement, falsification of certificates etc. After the completion of the investigation by these committees, they make recommendations and submit them to the Inspector General for approval/action.

In 2016, 430 cases of corruption were reported to the office, with different levels of difficulty or complexity. Each case is classified according to this complexity and hence the amount of time required to investigate the case. Complex cases need to be reviewed and monitored, or they may need more evidence to complete the investigation. Complex cases include embezzlement, bribery and stalling in the completion of infrastructure projects. Medium cases include fake certificates of hired employees. Simple cases include the disappearance of official documents and damage to property. Based on historical records of 2016, 35% of cases each year are of simple level, 40% are medium and 25% are complex. There is an average rate of 35 cases arriving per month, giving an annual number of about 430 cases.

Committees consist of three employees of certain experience levels depending on the complexity of the case. There are 72 employees who participate in the committees with different level of experience. The employees adhere to a scale of seven levels. A new employee comes in at the 7^{th} or 6^{th} level (inexperienced), while the employees with some experience are at the 5^{th} level and the high experienced are at second, 3^{th} and 4^{th}

levels. There are just two employees with level one in GIO and their function is to assist the Inspector General. Their availability is limited for investigation committees.

Table (1) shows number of the employees according to their experience level.

Table (1) Number of Employees

	Inexperienced	**Experienced**	**High experienced**
Number of employees	**22**	**30**	**20**

The Director of Investigations is responsible for creating the investigation committees for incoming cases. These cases are not known in advance as to their complexity level or exact arrival time, hence planning the allocation of staff is difficult. Currently, the creation of these committees is done in no particular way. Whoever is "around" or can be taken off other case is potentially suitable. This kind of arrangement is done without taking the experience level of the employees into consideration. As a consequence, the committees do not function well.

Inefficient allocations of employees to cases can occur. For example, if highly experienced employees are involved with simple cases, then when a complex case arrives, there are no highly experienced staff to deal with it effectively. This leads to delays in completion before the deadline. Complex cases are very important. If a major infrastructure project has a case, then this type of case, above others, must be solved as soon as possible to allow the contractor to finish before the deadline.

A good example for current assignment to committees is, consider a corruption case related to building a power plant or water treatment plant. Any delay is of national importance. Another example of the importance of a good schedule may occur when an employee embezzles a sum of money or takes a bribe to pass a certain transaction. The office gets a letter from the complainant who may be an employee in the same department. A delay in processing this kind of case may lead the suspected corrupt employee to continue taking bribes and putting the complainant at risk.

1.2 Allocation of employees to committees

Since the type, duration and arrival of cases is unknown, this makes it difficult to draw up a plan for scheduling and allocating employees to the cases. Instead, we need to evaluate likely outcomes of different ways of allocating the work to the different skill levels available under this uncertain environment.

Figure (1) shows an example of an allocation of employees to committees. There are three sets of employees according to their experience level. The committees will be formed with three employees and allocated to a particular case.

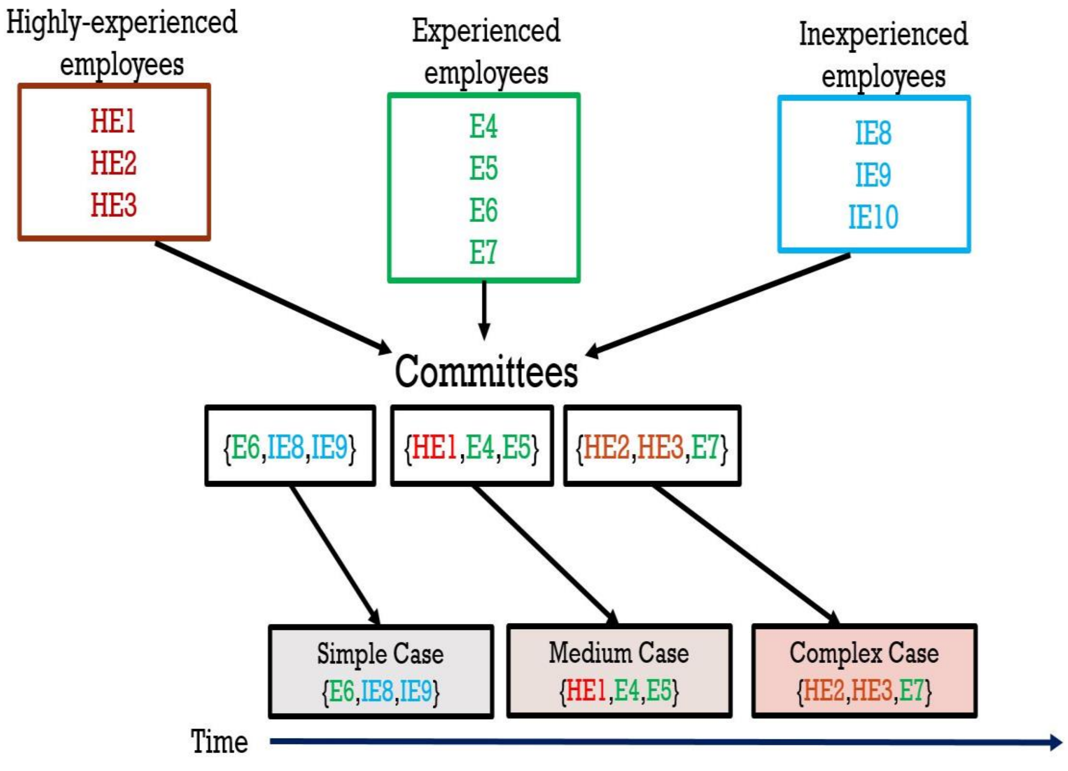

Figure (1) Allocation of employees to committees and to cases

According to the annual report of GIO for the year 2016 (Figure (2)), 422 committees were created in 2016. Just 242 cases were completed before the deadline by the end of 2016 year. The remaining cases were still in progress. That give us 57% as a percentage of completed cases for the year 2016.

التقرير السنوي لمكتب المفتش العام لعام ٢٠١٦

الفصل الثالث
نشاطـــات المكتـــب

أ- عدد القضايا التي تم التحقيق فيها خلال عام ٢٠١٦ على النحو الآتي:

تم تشكيل (٤٢٢) لجنة تحقيقية ، أنجز منها (٢٤٢) لجنة ، و أنجاز (١٩٣) لجنة عن الاعوام السابقة يصبح المجموع الكلي للجان التي تم انجازها لعام ٢٠١٦هو (٤٣٥) لجنة.

ب- اجمالي مبالغ قضايا الفساد التي استكمل التحقيق فيها او قيد التحقيق .

• المبالغ المخمنة (الموصي باستردادها) نتيجة التحقيقات لعام ٢٠١٦ بلغت (٢٢,٢٢٩,٧٩٣,٦٨٢) اثنان وعشرون مليار ومائتان وتسع وعشرون مليون وسبعمائة وثلاث وتسعون الف وستمائة واثنان وثمانون دينار .

ج- اجمال مبالغ قضايا الفساد التي صدرت بها احكام قضائية نهائية .

لا توجـــــــــــد

د- أجمالي المبالغ التي تم استردادها فعلا لصالح الخزينة العامة للدولة :-

❖ بلغت المبالغ المستردة (٣,٧٤٨,٠٤٥,٠٧١) ثلاثة مليارات وسبعمائة وثمانية واربعون مليون وخمس واربعون الف وواحد وسبعون دينار.

هـ- المبالغ التي تم منع هدرها :-

❖ (١٧,٠٠٠,٠٠٠,٠٠٠) سبعة عشر مليار دينار عن شراء اليات / كربلاء المقدسة .

و- العقارات التي تم اعادتها وتقديراتها :-

❖ تم استرداد عقارات بعدد (٢١) عقار في كـــــربلاء المقدسة وبلغت قيـــمة مبالغ (٢٠) عـــقار منها (١,٤٦٠,٠٠٠,٠٠٠) مليار واربعمائة وستون مليون دينار.
❖ تم استرداد عقارات بعدد (٨) عقار في محافظة ذي قار وبلغت قيمة العقارات (٢٢١,٠٠٠,٠٠٠) مائتان وواحد وعشرون مليون دينار.
❖ استحصال مبالغ عن مساحات زائدة في قطع الاراضي (فضلة) بلغت قيمتها (٢٧٦,٢٥٥,٦٠٠)مائتان وستة وسبعون مليون ومائتان وخمس وخمسون الف وستمائة دينار / مديرية بلديات واسط .

٢٠

Translation

422 COMMITTEES WERE ESTABLISHED, JUST 242 WERE COMPLETED BEFORE END OF 2016.

Figure (2) 2016 GIO Report.

1.3 Simulation

Resource allocation in an uncertain environment can be solved using simulation. We propose and simulate several work practices, analyze the results and propose the best for the Office. By work practices we mean using different priority rules for selecting cases from queues, flexibility in allocation of employees and additional employees.

However, simulation relies on data. In our case, it will be from historical data including:

1. Case types: Complex cases, medium cases, simple cases.
2. Resources: Number of GIO employees according to their experience levels.
3. Case handling time distribution.
4. Inter-arrival time distribution for cases.

Arena Software [2] from Rockwell Automation is used in this research. It is an industry standard software. Research [3, 18] have been carried out using this software because it allows the analysts to create an animated simulation model that helps accurately represent virtually any system. For each model, the software provides output related to the waiting time for cases, the average number of the cases in queues, the number of completed cases and the utilization of the employees.

We can model different work practices and simulate them many times. Each replication of the simulation has random input of arrival times, types of case and duration.

The software provides using varies dispatch rules, i.e., selecting the next case from a queue according to some criteria such as FIFO (First in, First out) which means priority is given to the first case that arrives, or LIFO (Last in, First out).

1.4 The Research Proposal

This research proposes new practices of handling corruption cases in the GIO. For this we need simulation due to the uncertain environment in which the work takes place. The simulation results for each model can prove to the manager that there are different ways of ordering, staffing and executing the work which will make a difference to the performance of the office. These changes to the working practices can save time and effort in reducing the spread of corruption.

The problem has features which together generate a non-standard modelling challenge. These are different ways of allocation for employees to cases, the uncertain arrival times and cases duration.

As far as we know, simulation has not been applied to the area of corruption teams and certainly not in Iraq, which makes a unique problem. This has created a strong motivation to try to find a solution to reduce corruption for the benefit of Iraq and its people.

CHAPTER 2

LITERATURE REVIEW

2.1 Modeling and Simulation

Using simulation in an uncertain environment can provide insights on possible outcomes with confidence levels, for decisions makers. The research by Hauser, et al., [3], try to find a solution for decision makers to be confidence in their decisions. They found that the simulation approach is better than traditional decisions making. In our research, using simulation for different work practices will help us determine the weakness in GIO operations and help decisions makers choose the best work practice for the Office.

Simulation has been used in many areas [8], such as medicine, communications, manufacturing etc. to understand the impact of queuing and allocation of the resources.

Simulation has become a widely used tool to manage manufacturing production, because it provides matching features for that environment, such as allocation of jobs to machines [4, 5] and by allowing rules such as First Come First Served (FCFS) and Shortest Process Time First (SPTF). Simulation can also model queues and measuring the length of the machine queue is often an important way of evaluating a simulation model [6]. Equally, resource utilization is another important measure which simulation models [7].

In the example of Starbucks [9], the researchers simulate the uncertain arrival time of customers and queues. The researchers needed to know of the queue and average waiting time of the customers to improve the efficiency of the Starbucks cafe. In our research, we want to know how many cases are waiting in the queue and the average waiting time for cases.

Evans et al [10] proposed a model for evaluating schedules of nurses and doctors in a hospital emergency department and simulate it using ARENA. The models one used to evaluate the length of stay of 13 types of patient. In our research, we will use three different types of cases which are simple, medium and complex cases and evaluate the average waiting time for these cases.

Simulation research in hospitals [11, 12] seeks to find the perfect allocation rule of operating room resources for patients. The allocation of operating rooms (committees) in uncertain environments to operations (cases) is an important aspect of our research. We will find the best performing of allocation rule under uncertainty, then we can apply this to real-life.

The research by Alwadood et al. [13] describes a staff-scheduling model that will help reduce the average time for jobs in the system and increase the number of completed jobs in the maintenance department of information technology company. The problem is when service demands arrive, the assignment of the staff to this demand is done by the supervisor. Our research seems to be close, as the allocation of employees is done by the manager. However, as a measure of performance, we are focusing on average waiting time, number of completed cases, average number of cases in queue and the utilization of the employees.

2.2 Dispatch rules

Dispatch rules have been much studied by researchers in different areas such as manufacturing and medicine. Dispatch rules play an important role in our research as they provide a way to improve the KPIs in the office. Dispatch rules in particular decide which case to process next from the queue

A simulation study of dispatching rules in stochastic job shop dynamic scheduling [14] evaluates several dispatch rules in a theory of dynamic scheduling problem with random job arrivals and stochastic processing times. This is similar to our situation in the arrivals and processing times, but we have the extra dimension of a choice of resources making up the committees. They consider many dispatch rules similar to what we are using and they achieved success using longest process time first (LPTF) because the number of completed orders was better with this rule.

The research by Ghaleb et al. [16] consider simulation of the queueing of students being served over time at a university restaurant. They worked on a queuing model providing good work practice to face the ‘rush hours’ in the restaurant. They found that combining some services and removing others, will reduce the queue length. Here, the students (cases) was not like ours, as there were known times of high demand and others of low demand.

Simulation in the semiconductor industry [15] looks at different ways of choosing the next task to schedule and simulates the arrival of orders. Shortest process time first (SPTF) achieved the highest throughput of tasks in the time window. In our research, the number of completed cases is important, so we will evaluate this rule by tracking the number of completed cases.

Simulation in the job shop scheduling [17] looks at several ways of modeling schedule of the trains on the tracks (trains considered as jobs). Here the dispatch rule of first come, first served (FIFO) minimized the delay for the trains (leads to minimizing the travelling time). FIFO, is also one of the rules that we used in our research.

CHAPTER 3

METHODOLOGY

In this chapter, we will describe how we simulate the possible different work practices to be able to evaluate the likely outcomes of performance. Two types of data set were used: small amount of “toy” data and full amount of real-life data.

3.1 Input to the simulation

To apply simulation to the work of GIO, we need to base it on existing work flows and practices. In particular, we need to obtain real-life data on:

1. Inter-arrival times of cases. We test our historical data whether it followed a normal distribution. For this, we use the Chi-Square hypothesis test. The null hypothesis is that the historical distribution of case inter arrival times resembles a normal distribution. To prove this, if there is a big statistical difference between the observed and theoretical, then, we will reject the null hypothesis and the data not fit the normal distribution. If there is not a big difference in the distribution of the inter arrival times, we will not reject the null hypothesis and the data adheres to a normal distribution.

In our research, the historical data fit a normal distribution (mean=10, standard deviation=9) for the arrival time of simple cases. For medium cases normal distribution (10,7) and for complex cases normal distribution (15,9). As well as the work in literatures [14, 19] where arrival times usually have a normal distribution.

2. Composition of cases (simple, medium and complex). According to the annual historical GIO reports, 35% are simple cases, 40% are medium and 25% are complex.

3. Duration of a case depends on its complexity. Each case type is a uniform distribution of duration. The uniform distribution values for simple cases are [5, 8] days, medium cases are [7, 10] days and for complex [14, 21] days.

4. Number of employees according to their experience level. It will be real-life number of GIO employees as 22 inexperienced, 30 experienced and 20 high experienced.

3.2 Simulation of work practices

In this section, we will define the precise inputs to simulate our different work practices on different data sets.

3.2.1 Validation of model with a small amount of data

By way of validating our simulation models, we will start with a small example to understand how our simulation model works on a few cases and employees. We will understand and explain the answers from these models. We assume the following,

- 16 cases (10 simple, 4 medium and 2 complex).
- 9 employees (3 for each level of experience).
- The simulation will last for 30 days, 7 hours of working per day.
- One replication.
- First in, First out queue selection rule.
- The processing time will be randomly selected from a uniform distribution of 1-3 days for simple cases, 2-4 days for medium cases and 3-7 days for complex cases.
- A fixed allocation of employees to committees - one experienced with two inexperienced employees for simple cases, two experienced with one inexperienced employees for medium cases and two high experienced with one experienced employee for complex cases.

3.2.2 Verification of model with real-life

In order to verify the model, we will relate it to some real-life inputs. Figure (3) shows the distribution of cases' arrival times.

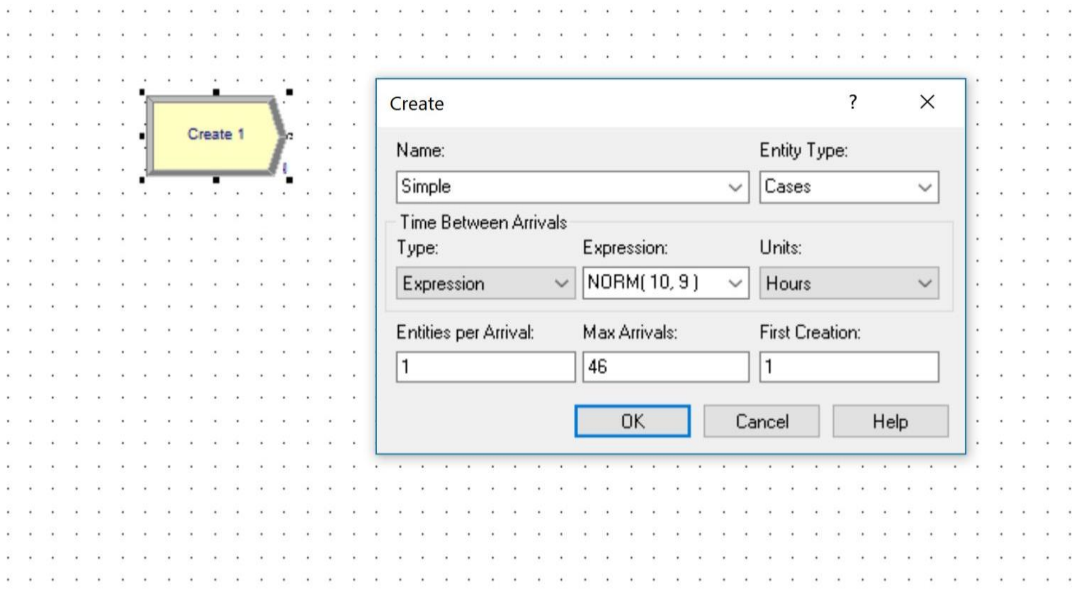

Figure (3) Distribution of cases' arrival time

As we see in Figure (3), we can determine the number of arrival cases in Max Arrivals part. It will be 46 simple cases, 53 medium cases and 34 complex cases, these values are based on historical data. As well as the determination of the normal distribution values in Expression part.

Figure (4) shows the resources inputs. In our research, the resources will be the real-life number of the employees, which is 72 employees.

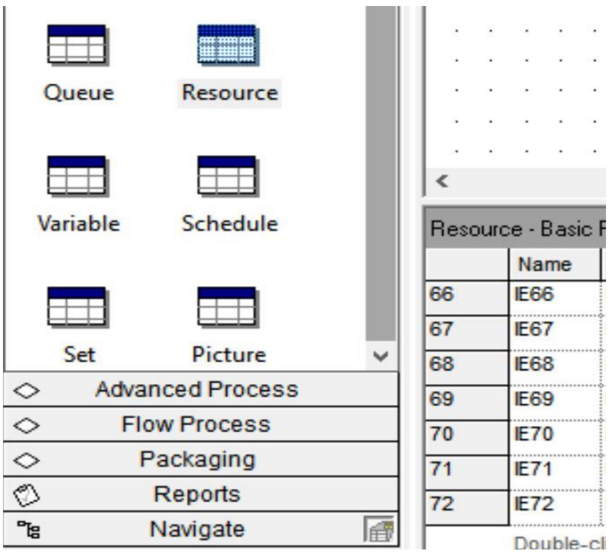

Figure (4) Resources input.

Figure (5) shows the queue dispatch rule. When cases get queued, a dispatch rule will be used to select the next case from the queue. In this case, the selection of next case from the queues based on the rule first case in, first out.

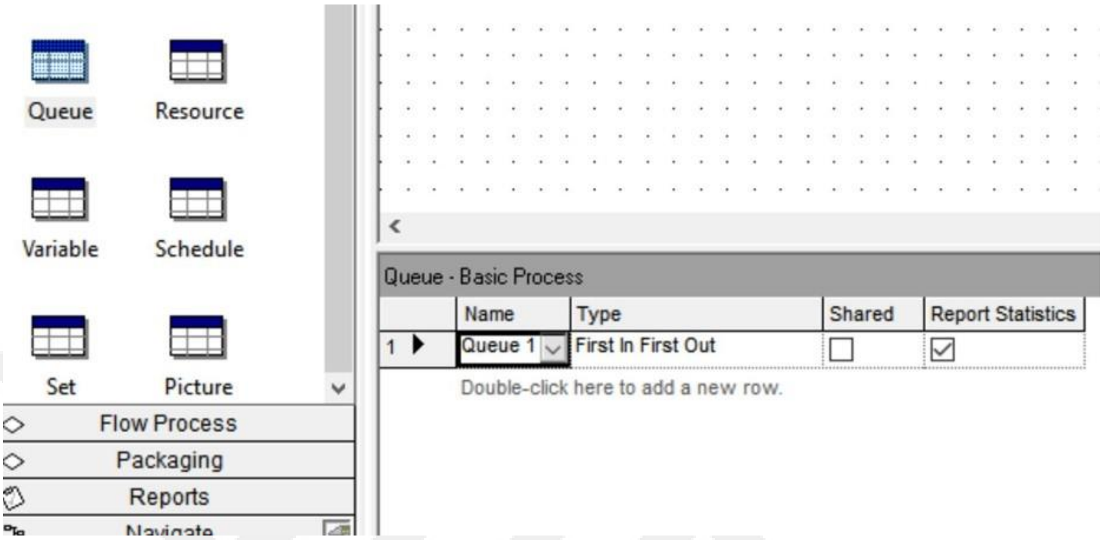

Figure (5) Queues rule

Figure (6) shows processing time of cases. This model contains the employees who will process the cases. A uniform distribution [1-3] is used to determine the processing time for simple cases, uniform distribution [2-4] for medium cases and uniform distribution [3-7] for complex cases.

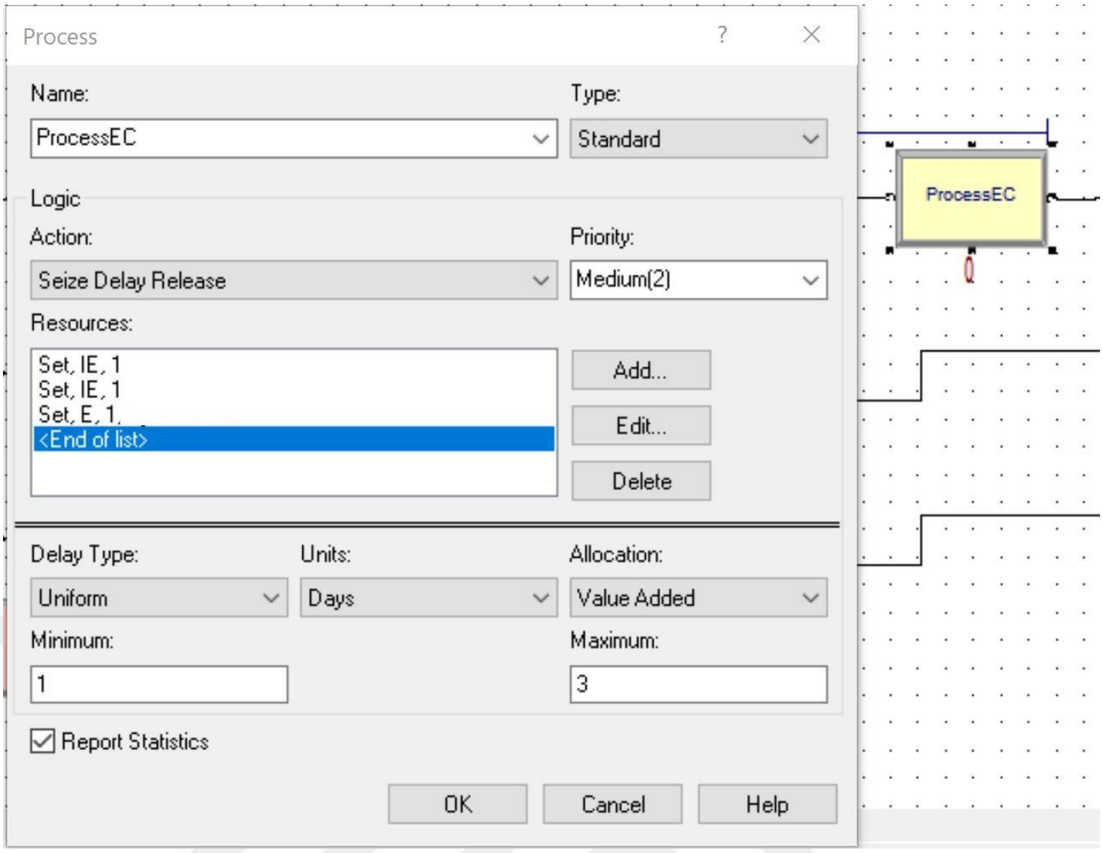

Figure (6) Processing time of cases

3.2.3 Work Practices with full amount of data

We will model and evaluate several possible, real-life work practices based on the following inputs,

- 135 cases, based on the actual historical distributions (35% simple, 40% medium and 25% complex) so we have 47 simple cases, 54 medium and 34 complexes.
- 72 employees (20 high experienced, 30 experienced and 22 inexperienced).
- The simulation will last for 88 days (4 months without holidays), 7 working hours per day.
- 30 replications.

We will develop simulations for the different work practices, to be evaluated against several KPIs. We will vary two main factors to create each configuration of the work practice. They are as follows.

A. Handling of the queue of waiting cases

As the first cases arrive, they are immediately worked upon. After the first few, there are typically no staff available to start working on new cases immediately. Therefore, they are put into a queue. We assume that a queue will develop naturally without enforcing one, because of the balance between expected work and resources available. With a queue in place, we have to choose the next case to be processed from this queue, if sufficient people and skills are available. Several rules can be used to choose the next candidate task. The rules are as follows.

- FIFO (First in, First out), priority is given to the first case that arrives.
- LIFO (Last In, First Out), priority is given to the last case that arrives.
- SPT (Shortest Processing Time), priority is given to the shortest expected processing time or time to investigate the cases. This effectively means priority for simple before medium and medium before complex in the queue.
- LPT (Longest Processing Time), priority is given to the longest expected processing time. This effectively means priority for complex before medium and medium before simple.

Other 'industry' dispatch rules have been considered, but rejected because they are not suitable for our work. For example, we have not considered, SIPT (Shortest Imminent Processing Time) where priority is given to the shortest individual processing time and LIPT (Longest Imminent Processing Time) where priority is given to the longest individual processing time. This is because those two rules are equivalent to SPT and LPT in our problem.

B. The allocation of employees to committees

There are two types of allocation, fixed and flexible.

i. Fixed allocation means that the assignment of the employees to a case has only one option. In other words, complex cases are handled by exactly two highly-experienced and one experienced employee. Medium cases are handled by two experienced employees and one inexperienced employee. Simple cases are handled by two inexperienced employees and one experienced employee.

ii. Flexible allocation means permits several possible allocations for medium and complex cases only. These types of cases are more important to get started and eliminate corruptions. Therefore, giving alternatives on how they can be resourced, may help this. Flexibility will allow for complex cases to be composed of two experienced employees with one highly-experienced employee, or two highly-experienced employees with one experienced employee, or even three high experienced employees or three experienced employees. For medium cases flexibility will allow to be composed of two experienced employees with one inexperienced, or two experienced employees with one highly-experienced, or one experienced employee with two highly-experienced employees.

Figure (7) shows the flowchart of creating committees and allocating cases within the simulation model.

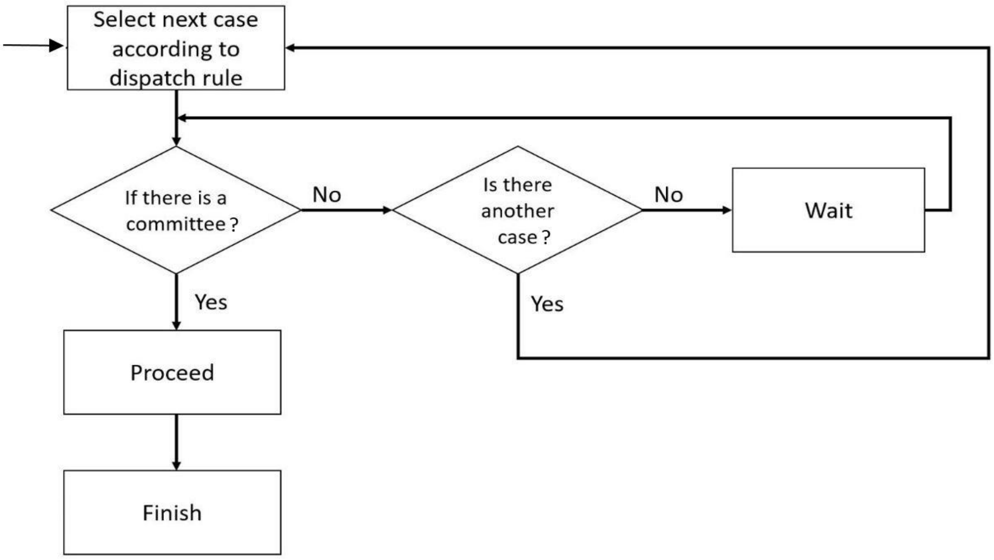

Figure (7) Flow of Creating Committees and Allocating Cases within the Simulation Model

3.3 Output and evaluation

We have identified four key performance indicators (KPIs) which will be used to compare the results of the various work practices. These KPIs are:

- Number of completed cases (NCC) – this represents a measure of the amount of work the employees carry out in the time window.
- Maximum queue length (MQL) – measure of the maximum number of cases waiting to be assigned at any one time.
- Average waiting time (AWT) – this is how long on average a case takes before starting.
- Utilization of the employees (UOE) – this is a measure of how busy the employees are. It depends on the workload over time and the number of employees.

CHAPTER 4

RESULTS

In this chapter, we will present three different sets of simulation results. The first set demonstrates the validity of our simulation model by applying it to a single work practice (FIFO + Fixed) and a small amount of data. The second set extends the first, across eight work practices and with real-life data. Finally, the third set is obtained by varying the amount of inexperienced employees available for a single work practice (LIFO + Flexible) and real-life data.

4.1 Single work practice, small amount of data

By observing the results for a simulation of a work practice with small amount of data, we can confirm, to an extent, that the model is working. Due to the low quantity of resources and tasks involved and the single pass simulation, it makes it possible to determine by observation, whether the results are plausible. Table (2) shows the schedule of a simulated work practice in sequential order.

Table (2) Schedule of the cases

ID	Cases Type*	Arrival Time	Waiting Time	Processing Time	Completed Time
1	1	1 day	0	1 day 5 hours	2 days 3 hours
2	1	1 day	1 day 4 hours	1 day 2 hours	3 days 5 hours
3	2	1 day 4 hours	0	2 days	3 days 6 hours
4	1	4 days 1 hour	0	3 days	7 days
5	2	5 days	0	3 days 5 hours	8 days 6 hours
6	1	4 days 2 hours	3 days	2 days 4 hours	9 days 5 hours
7	1	6 days 6 hours	3 days	2 days	11 days 6 hours
8	1	6 days 6 hours	5 days	1 day 4 hours	13 days 2 hours
9	3	7 days	1 day 4 hours	6 days 6 hours	15 days 3 hours
10	1	12 days 3 hours	1 day	3 days	16 days 4 hours

11	1	12 days 4 hours	3 days 6 hours	3 days	19 days 2 hours
12	3	9 days 4 hours	5 days 6 hours	6 days 3 hours	22 days
13	1	15 days 3 hours	3 days 6 hours	2 days 4 hours	22 days
14	1	15 days 4 hours	6 days 3 hours	2 days 2 hours	24 days 3 hours
15	2	9 days 2 hours	12 days 4 hours	3 days 3 hours	25 days 3 hours
16	2	12 days	13 days	2 days 3 hours	28 days

* Cases Type	Duration
1 - Simple Cases	[1-3]
2 - Medium Cases	[2-4]
3 - Complex Cases	[3-7]

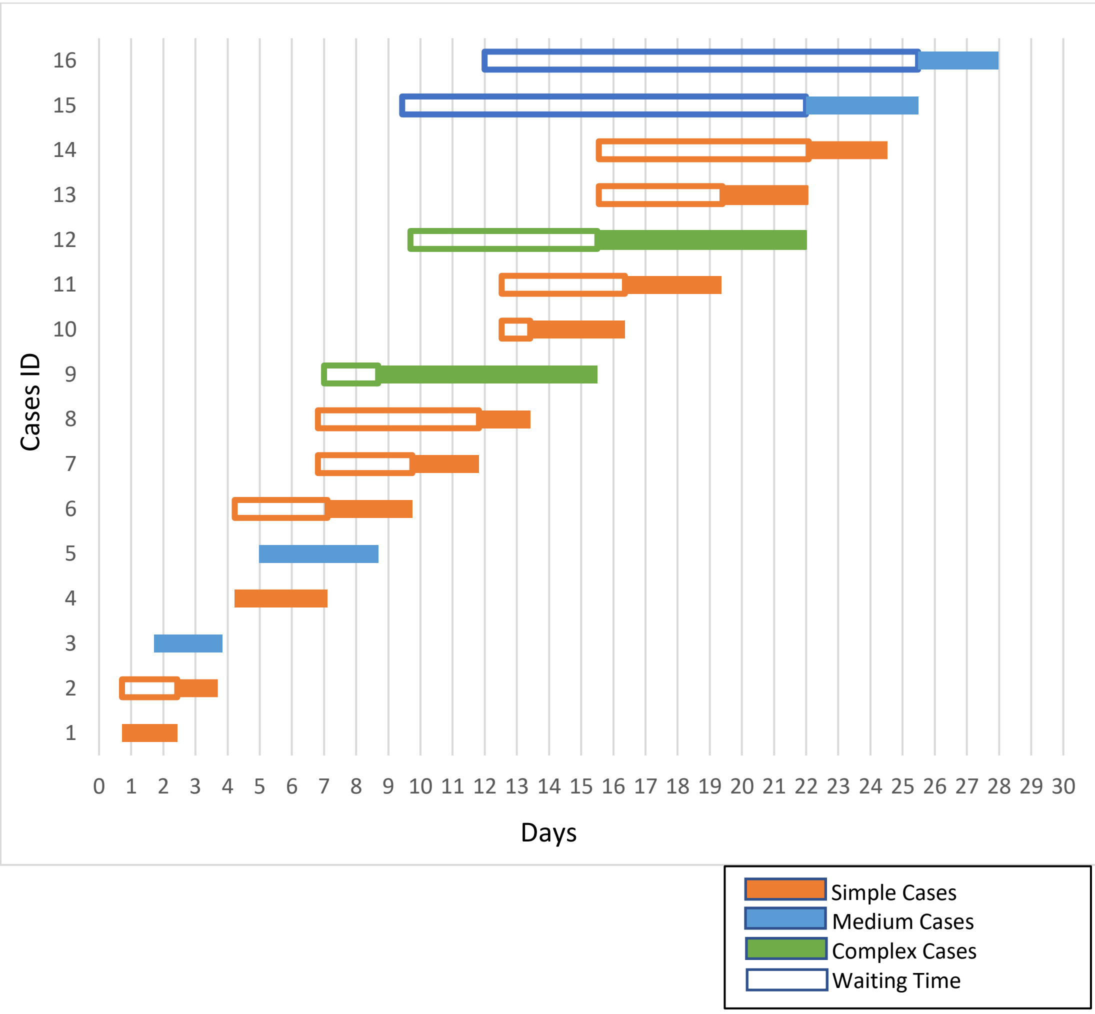

Figure (8) MQL for cases

The MQL for this work practice is 5 cases which occurs between the day 12.5 and 13.5. Figure (8) shows the MQL for cases, by calculating the maximum parallel outlined rectangles.

The design of this simulation is that all cases will be complete and so NCC is 100%. From Table (2), ID1 and ID2, both simple cases, were the first to arrive. It followed that, two inexperienced and one experienced employee are allocated for ID1 - now only one inexperienced and two experienced employees remain. Therefore, ID 2 had to wait in the queue for one inexperienced to be available. This only happened after ID1 completed on day 2 days 3 hours as there was nothing else in the queue.

The next medium case, ID3, could immediately start because it needed two experienced and one inexperienced - both are available.

At the end of day 3, three inexperienced and three experienced employees became available from ID1, ID2 and ID3, so the third simple case, ID4, could start.

Later, when ID9 case arrived (complex), it needed two high experienced employees and one experienced employee. As the results imply, the complex case had to be wait because all experienced employees were involved with the medium cases that had arrived before.

Table (3) shows the AWT results. AWT for all cases is 4 days 3 hours. We note that medium cases are the highest AWT than the others because medium cases need two experienced employees and experienced employees are in high demand across all cases, even though there are proportionally more of them.

Table (3) AWT results

Cases types	Average
Simple Cases	2 days 5 hours
Medium Cases	6 days 3 hours
Complex Cases	3 days 5 hours
Overall	4 days 3 hours

In order to understand how this arises when the first complex case ID 9 arrived, the allocation of employees done after two days because in that time just the simple cases are in process (need just one experienced employee for each case). That means ID 9 had to be wait in the queue. Then two simple cases arrived ID 10 and ID 11 and had to be wait in the queue for experienced employees (one of them involve with ID 9 and the others with ID 8 and ID 7. Then two medium cases ID 15 and ID 16 arrived in the queue, but there were no experienced employees available. Therefore, the queue length will reach 5 cases.

The Utilization of Employees (UOE) depends on the workload over time and the number of employees. We group the employees into sets according to their experience level to get a clear breakdown of the UOE. Figures (9, 10 and 11) show the utilization of inexperienced, experienced and high experienced across the 30 days. The actual UOE figures are 63%, 59%, 29% respectively.

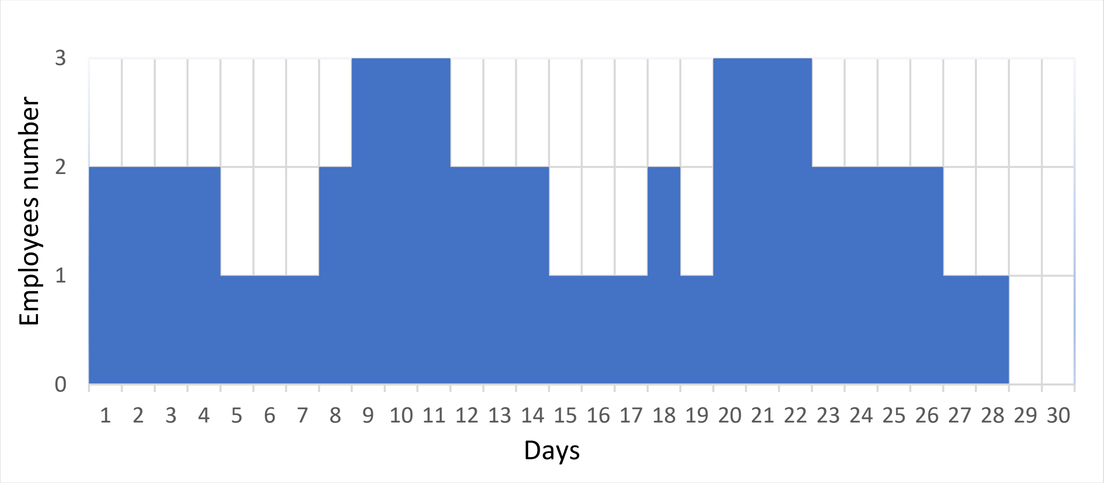

Figure (9) Utilization of inexperienced employees

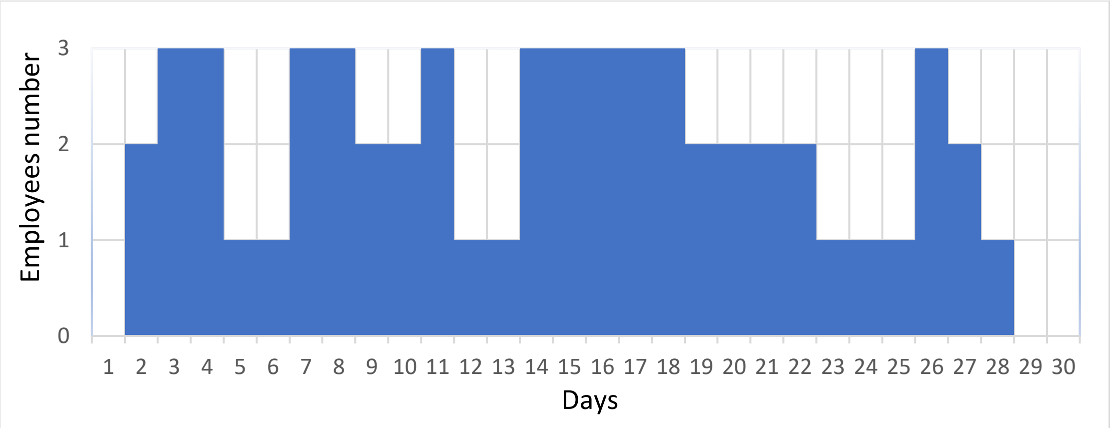

Figure (10) Utilization of experienced employees

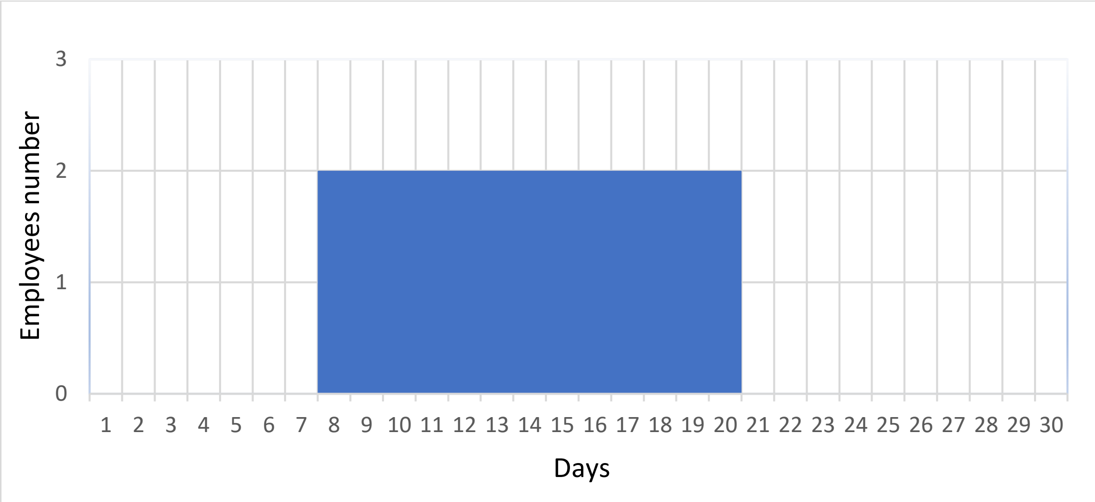

Figure (11) Utilization of high experienced employees

The experienced employees are involved in 16 cases (all types), while the inexperienced are in 14 (simple and medium). This gives us a likely reason why the UOE between the sets of experienced and inexperienced employees is similar and much greater than the high experienced (only 2 cases).

From figure (9) by way of validation, we see that between days 14-19, all experienced employees are working: two of them are involved in two simples (other two simples are waited) and the other one involved in complex cases. Hence the schedule reflects this (figure (8)) by the arrival of ID 12 which had to be wait 6 days for one experienced employee to be available.

In order to further validate the model through the results, we generated a second set of arrival times and case types. Table (4) shows all KPIs with new data set. We found that some KPIs were affected by the different pattern of arrival time and cases. AWT and MQL are improved with the second data set.

If the case arrived and by chance there were available employees, the allocation will be done immediately. So, the AWT will be decreased and hence the MQL is likely will be decreased too.

Table (4) All KPIs with new data set

KPIs	First data set	Second data set
AWT	4 days 3 hours	2 days 1 hour
MQL	5 cases	3 cases
NCC	100%	100%
UOE	Inexperienced 63% Experienced 68% Highly experienced 31%	Inexperienced 63% Experienced 68% Highly experienced 31%

In summary, the second data set gave similar results and still gave clear indication that the results were correct in being plausible and explainable. This gives us the assurance to now use the model for real-life work practices.

4.2 Work practices in terms of real-life data.

We now scale up the data to realistic levels (time period, number of cases, process times, number of employees and number of simulations passes) and evaluate eight proposed work practices in terms of our defined KPIs.

Table (5) first shows the NCC results. The best solution for this indicator is with LIFO + Flexible with 99% successful completion. All other queue dispatch rules with Flexible were very close, in the 94’s. Flexibility give us more options to solve cases sooner and sometimes those options make a difference to the NCC.

Table (5) NCC results

Work practices	NCC			
	Simple Cases (46)	Medium Cases (53)	Complex Cases (34)	Total Finished (135)
FIFO + Fixed	45	49	32	126 93%
FIFO + Flexible	46	52	31	129 96%
LIFO + Fixed	46	53	24	123 91%
LIFO + Flexible	46	52	34	133 99%
LPT + Fixed	45	52	15	112 83%
LPT + Flexible	45	52	30	127 94%
SPT + Fixed	46	52	21	119 88%
SPT + Flexible	46	52	32	130 96%

If we use the longest or the shortest processing time first with a fixed allocation, we will get unsatisfying solution for NCC, so we need to perhaps mix up the cases. There is no explicit mix up strategy, but we are doing FIFO and LIFO and the cases already arrive fairly mixed up.

In order to show why this might arise, Table (5-B) shows cases ordered mixed as S, M, S, M and Table (5-C) shows cases order as S, S, M, M. We have two simple (S) and two medium (M) cases with three inexperienced and three experienced employees and adopt a FIFO strategy. Those two tables show that if the order of arrival of cases changes then the average waiting time will be change too. We can note that the AWT of S, S, M, M is worse than S, M, S, M in terms of just four cases (two simple (S) and two medium (M)).

Table (5-B) First cases order

Case Type*	Arrival Time	Waiting Time
S	1 day	0
M	1 day 5 hours	0
S	4 days 2 hour	0
M	5 days	0

Case Type*
S=Simple
M=Medium

Table (5-C) Second cases order

Case Type	Arrival Time	Waiting Time
S	1 day	0
S	1 day	1 day 5 hours
M	1 day 5 hours	0
M	1 day 6 hours	2 days

Case Type*
S=Simple
M=Medium

Table (6) shows the normalized AWT for the different work practices. The simulation provides us the AWT of just the completed cases. In order to make a valid comparison across all work practices, we normalized the AWT for a minimum number of cases (100) which every work practice completes.

We get unsatisfying solution for LPT and SPT using fixed allocation, being two days in each which are the largest values than other work practices.

Table (6) Normalized AWT results

Work practices	AWT
FIFO + Fixed	2 hours
FIFO + Flexible	5 hours
LIFO + Fixed	5 hours
LIFO + Flexible	2 hours
LPT + Fixed	2 days
LPT + Flexible	1 day 6 hours
SPT + Fixed	2 days 2 hours
SPT + Flexible	1 day

The AWT of complex cases is a key measure for us. Therefore, Table (6-B) shows AWT results for each type of cases. Focusing on complex cases, FIFO (Fixed and Flexible) LIFO Flexible were both good. Hence LIFO + Flexible scores well on both NCC (throughput) and AWT for complex cases.

Certainly, the complex cases dominate the AWT as we can see from Table (6-B) and so this rather skews the above results in Tables (5-B and 5-C).

However, the nature of problem is, resources are usually tied up when we want to start a complex case. If we really want to start complex cases then we should allow interruptible processes.

Table (6-B) Normalized AWT results across each type of cases

Work practices	AWT			
	Simple Cases	Medium Cases	Complex Cases	Average
FIFO + Fixed	3 hours	1 hour	1 hour	2 hours
FIFO + Flexible	1 day 4 hours	1 hour	1 hours	5 hours
LIFO + Fixed	1 hour	1 hour	1 day 4 hours	5 hours
LIFO + Flexible	3 hours	1 hour	1 hour	2 hours
LPT + Fixed	2 day 4 hours	1 day 6 hours	1 day 2 hours	2 days
LPT + Flexible	1 day 6 hours	1 day 2 hours	2 days 1 hour	1 day 6 hours
SPT + Fixed	6 hours	1 day	4 days 6 hours	2 days 2 hours
SPT + Flexible	5 hours	4 hours	1 day	1 day

Table (7) shows the normalized MQL results, for 100 cases. Again, flexible always improves over fixed, in some cases as much as seven times. Similar to NCC with a fixed allocation the 'random' FIFO/LIFO outperforms the LPT/SPT.

Table (7) MQL normalized results

Work practices	MQL (Cases)
FIFO + Fixed	2
FIFO + Flexible	1
LIFO + Fixed	5
LIFO + Flexible	3
LPT + Fixed	10
LPT + Flexible	2
SPT + Fixed	7
SPT + Flexible	1

Table (8) shows the UOE results, for the different work practices. The overall UOE for FIFO and LIFO is 62% while the UOE for LPT and SPTF is 51%. FIFO and LIFO are essentially random allocations, while LPT and SPTF tries to prioritize certain types of cases. Most efficient use of resources is by using a semi-random approach as we showed above in table (5-B). So, we found that using FIFO and LIFO will give us the best solution over LPT and SPTF.

Table (8) UOE results

<table>
<tr><th>Work practices</th><th>UOE (Percentage)</th><th>Overall</th></tr>
<tr><td>FIFO + Fixed</td><td>58%</td><td rowspan="4">62%</td></tr>
<tr><td>FIFO + Flexible</td><td>62%</td></tr>
<tr><td>LIFO + Fixed</td><td>63%</td></tr>
<tr><td>LIFO + Flexible</td><td>63%</td></tr>
<tr><td>LPT + Fixed</td><td>42.%</td><td rowspan="4">51%</td></tr>
<tr><td>LPT + Flexible</td><td>59%</td></tr>
<tr><td>SPTF + Fixed</td><td>46%</td></tr>
<tr><td>SPTF + Flexible</td><td>58%</td></tr>
</table>

LIFO with both types of flexibilities is clearly the best solution for UOE, while LPT, SPTF + Fixed are the worst solution for UOE indicator.

4.3 Increase the employees with LIFO + Flexible

Every year GIO hires new employees. These new employees are only hired at level 7, which means that they are inexperienced. The number of hired employees depends on how many old employees retire. It has never been more than three employees per year. During the year, employees get promoted and so roughly the same profile persists year on year.

We therefore evaluate increasing the inexperienced employees against real-life data, in order to understand its likely effect on the various KPIs. We choose to increase the inexperienced employees from 1 through to 3.

Table (9) shows the impact on the various KPIs from various increase in employees. We make this comparison only on work practice LIFO + Flexible because it was one of the best work practice from the previous evaluation.

The NCC indicator is almost unaffected by the number of inexperienced employees. We are not able to process more cases by increasing inexperienced employees. The extra employees are not critical to starting any cases earlier as we can see also from the AWT remaining relatively static.

We also note that utilization of inexperienced employees (UOE) is always decreasing because of the number of arrival cases stays the same, but with more employees.

Table (9) The impacts on the various KPIs from various increase in employees

ID	KPIs	LIFO + Flexible	Increase by 1 inexperienced employee	Increase by 2 inexperienced employees	Increase by 3 inexperienced employees
	NCC	98%	98%	98%	98%
1	MQL	29 cases	30 cases	30 cases	33 cases
2	AWT	1 day 2 hours	1 Day 3 hours	1 day 1 hour	1 day, 3 hours
3	UOE	IE=54% E=67% HE=69% Overall=63%	IE=51% E=67% HE=69% Overall=62%	IE=49% E=67% HE=69% Overall=62%	IE=47% E=67% HE=69% Overall=61%

There is not much we can say apart from no significant change, because the inexperienced are only used for simple cases and since these are more likely to be influenced by availability of experienced, then there is little impact. If we could take on more experienced employees, then that might make a difference to the KPIs, but this is not an option at the GIO

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

Certain work practices seem successful on certain KPIs. If we prioritize the KPIs to amount of work done and the average waiting time for complex cases, then we can say LIFO + Flexible is the best work practice. We note that the completed cases for last year was 57%, while the best LIFO + Flexible achieved 99%.

So, for the question of what we can do to help the GIO, it is to propose the work practice of using a LIFO dispatch rule for queue selection, in combination with a flexible allocation of employees. Flexibility in allocation helps to improve most work practices, because it gives us more options to solve the cases before deadline. In that way, we will solve more cases to eliminate the corruption in Iraq.

There are other work practices which achieve a satisfactory number of KPI's. Some of them get over 90% for NCC indicator (using flexibility), so we can consider them also as good work practices and discuss implementation issues with the manager. In general, it is easier to persuade the manager to implement the flexibility in allocation of employees than implementing formal queue system. In which case, the GIO will continue to select "randomly" the cases.

The manager does not care about what queue system is used, but he cares about how many cases are done before deadline and how many cases are waiting. This gives us the motivation to convince the manager not to use a fixed allocation because things are going to be worse.

In some work practices, we find that the UOE across the sets of employees are significantly different and this is not good because it means the work does not get distributed equally across the employees. This may create some problems at work.

This mismatch of utilization reflects the type of work coming in. If the work stays the same then the management might consider even more flexibility to achieve better utilization.

We can note that increasing one or three inexperienced employees for the LIFO + Flexible work practice does not improve AWT and MQL and UOE. However, employing an extra two inexperienced employees will improve the AWT. Therefore that option would not be recommended because the added employees are directed to cases which are already resourced enough.

In other words, there is no conclusive evidence that having more inexperienced employees will make a difference because the added employee/s are directed to cases which are already resourced enough.

Above all we have provided a language to discuss how cases are handled and also a model to measure alternatives against known KPIs. Each ministry has its own GIO, which monitors and investigates the work of that ministry. Therefore, this approach could apply equally to the other GIOs. We can propose this approach for them to introduce new work practice which will improve their efficiency and transparency.

In future, we consider applying some of the work practices to other GIOs because they have the same problem in work. If particular work practice is adopted, then better possessions to look up to other problems, because we have a better-quality data.

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