Chapter 3

Methodology

The model for the BAP consists of various sub components which are dependent upon each other. The following is a list of such components that embody the BAP.

* Demand
* Supply
* Expiry
* Importation
* Blood compatibility
* Blood unit daily remainder

Due to the different aspects which make up the BAP, it is necessary to break up each component in detail in the following chapter. The following chapter will also describe the blood issuing policy and overall structure of the blood bank.

Figure A

Step 9: Identify the best performing MH technique that was able to minimize the objective function

Step 8: Establish performance measures to evaluate results

Step 7: Record results achieved, and document the findings.

Step 6: Subject each MH technique to the datasets

Step 5: Randomly generate data.

Step 4: Create values which will be used as bounds for the datasets

Step 2: Generate algorithms and equations.

Step 3: Implement the MH techniques in conjunction with equations and algorithms from step 2

Step 1: Identify 5 different metaheuristic techniques to be modelled and an issuing policy for the BAP.

Figure A: Represents the flow of activities carried out for the methodology for the BAP

Step 1: Identify 5 different MH techniques which differ from previous research the tackle the BAP.

Step 2: As mentioned previously, the BAP is comprised of various mathematical components which will need adequate equations and/or algorithms to solve each component.

Step 3: Use the algorithms and equations from step 2 in conjunction with the MH techniques to work the problem.

Step 4: Due to confidentiality issues, datasets will be randomly generated values between certain percentage bounds.

Step 5: Using the percentage bounds, values can then be generated in accordance to each dataset.

Step 6: The values generated can then be implemented in each MH technique in order to find an optimal solution.

Step 7: Record the results achieved by each MH technique for all datasets and document the results in a meaningful way such as line graphs etc.

Step 8: The performance measures will identify which of the MH techniques achieved the best results.

Step 9: The best MH technique(s) in step 8 will be used for any real world applications.

3.1 Allocating Blood Unit Supply

The FIFO method proves most prudent when allocating WB units to patients. This method allows for the oldest units of blood to be used first in order to minimize wastage. All demands for a day must be met, therefore any blood types that have an insufficient supply (even after pulling additional units from compatible blood groups) will result in importing additional blood units from external sources. In this study, frozen WB units will be ignored, and only fresh WB units with a lifespan of 30 days will be considered. Figure B illustrates the process for allocating WB units to patients in need. As mentioned in chapter 1 the BAP model that is implemented tries to also accommodate data from a social aspect of the South African population. This social aspect was established by identifying trends in the demand and request of blood products on a yearly basis.

Figure B

Start

Are there traces of expired WB units?

Yes

Is day less than or equal to 365?

No

End

Yes

Yes

Update supply for the day

Calculate remainder for the day.

Fulfil demand for the day

Import additional WB units from external sources to meet the demand.

Yes

Is Demand greater than updated supply?

Yes

Pull additional units from the remainder of compatible blood types.

Is Demand greater than supply?

Remove expired units from blood bank, and update current useable supply

No

3.2 Particle Representation

Humans have 4 blood groups namely A, B, AB and O, each with a Rhesus value of either positive or negative, which therefore results in 8 different blood types. With this knowledge, the particles (or individuals) used in each MH technique will consist of an array of size 8. Each segment in the array will represent a specific blood type, with the array being of type double.

Figure C

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| A+ | A- | B+ | B- | AB+ | AB- | O+ | O- |

Figure C depicts the representation of a particle

3.3 Random Value Generation

Datasets used in this study of the BAP use percentage bounds to generate both demand and supply. The values for demand and supply consist of upper and lower bounds, a value within those bounds are then randomly generated in order to obtain a value. The BAP is coded using Java, it is therefore possible to use the Random class to generate a random amount.

Let:

RV: Represent a random value

Pu: Upper bound percentage

Pl: Lower bound percentage

M: Represent a specific month

Range: The difference between the upper and lower bound

Range = PuM – PlM (1)

RV = Range × Random.nextDouble() (2)

With reference to equation (Eq) 1, “.nextDouble()” is a method in Java which generates a random double value.

3.4 Demand

Demand relates to an amount of blood requested at any given time. As mentioned previously, unexpected demand for WB units can occur at any given moment. Demand for blood can therefore been seen as stochastic. The model implemented in this study follows a time frame of 365 days (1 year). The year is broken down into its months, with each month allocated a unique percentage range. The ideology behind this concept relates to the simple fact that demand experiences higher levels during months with more public holidays, vacation time, breaks from schooling facilities etc. Using this concept, months like December should have a higher percentage of demand due to most of the South African community being on leave from work, schools and tertiary institutes being closed. The lack of professional activity leads to more “riskier activities” being conducted such as drinking and driving which is one of the leading causes of road accidents in South Africa. If a day’s demand exceeds the supply on hand, compatible blood types will be considered (will be discussed later in this chapter) before importing additional units from external sources.

The months are broken up using the following day ranges.

Table A

|  |  |
| --- | --- |
| Months | Percentage Bounds (%) |
| January |  |
| February |  |
| March |  |
| April |  |
| May |  |
| June |  |
| July |  |
| August |  |
| September |  |
| October |  |
| November |  |
| December |  |

Using table A in conjunction with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ from chapter 1, it is no possible to use these values to generate a more appropriate daily demand amounts.

If we let

d= day, where 1 ≤ d ≤ 365

I = Initial blood volume in blood bank.

D represents a demand for a given day

Dd = I × RV (3)

In accordance to Eq 2, the demand for any day results in the initial volume multiplied by a random value from Eq 1.

3.5) Supply

When a patient receives whole blood transfusions, the donor and the recipient (the patient) must be of the same blood type, the patient can however use blood that is compatible with his/her own blood type. The supply for the day is a combination of the donations received for the current day plus the remaining units from the previous days.

If we let

S = Supply for the day.

Rc = Remainder from current day.

Rcb = Remainder of compatible blood.

D = Demand for the day.

d = day. Where 1 ≤ d ≤ 365

b = Blood type.

If the system is in the first day, then R equates to 0. To generate supply for the day

Sb = Sb + Rd-1 (4)

Eq. 4 relates to the initial calculation of the day’s supply. There are 2 scenarios that the blood bank can face when generating demand.

**Scenario 1**

Compare the demand of the day to the current supply of WB units on hand. If the demand is less than or equal to the supply, then the requests are fulfilled. After which the remainder is stored for next the day’s supply. The following algorithm illustrates the process for allocating supply to demand.

**Algorithm A**

If Sb ≥ Db Then

Sb= Sb – Db (5)

Else

Refer to scenario 2

**Scenario 2**

Compare the demand of the day to the current supply of WB units on hand. If the demand exceeds the supply on hand, then following steps are needed to try and fulfil the demand. Firstly, due to the feature of blood compatibility, blood types are matched against each other with compatible blood types being used to fulfil the remaining demands. For example, A+ blood is compatible with A-, O+, O-, it is therefore possible to use additional blood units from either of these 3 blood types to meet the demand for blood type A+. It must be noted that each blood type first tries and meets the demand of their own related blood type, only after the demand is satisfied, then the blood type can distribute the remaining units to other compatible blood types. If the blood type cannot meet the demand for the day, then its remaining value equates to 0, and cannot distribute to other compatible blood types. Finally, if the supply plus the compatible blood supply still cannot meet the demand, this will result in additional units needing to be imported to meet the demand.

If Db ≥ Sb Then

Pull additional units from compatible blood types

Sb = Sb + Rcb (6)

If Db ≥ Sb Then

Import additional blood units

Unlike generating demand which implemented a social component to the percent ranges, the supply will be calculated using a fixed percentage range between 25 – 75%, as donations do not follow a varying trend. In order to form an adequate equation to predict the amount of WB donations in a day, table 1 (in chapter 1) will need to be utilised. Table 1 indicates the percentage of the South African population with regards to blood types. In utilising the percentage of blood types, it allows for a clear depiction of the donation of whole blood units for a specific day, in addtition it will allow for a fixed array of size 8 which will minimize computational effort as opposed to using array lists of variable sizes.