Stock control of repairable parts

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1 Description of the problem

Competition in the computer hardware industry is extremely fierce. The margins on hardware have reached an absolute minimum and, partly for this reason, companies in this sector are shifting their focus to after-sales service. Since the economic lifespan of hardware is only a few years, it is important to bind existing clients by providing a high-quality service for the equipment supplied. However, the margins on after-sales contracts are also a welcome supplement to the falling profit margins on the hardware itself.

Maintenance contracts entered into with major clients, such as banks, universities or multinationals, require special attention. Major clients are tough negotiators when preparing service contracts and are particularly vigilant to the speed with which breakdowns in their equipment are restored. Failing computer equipment at banking institutions means a rapidly accumulating loss. Strictly defined conditions with regard to response times therefore often form a standard part of these service contracts. For instance, the contract stipulates that breakdowns in the hardware must be restored within 8 office hours of having been reported by telephone. Failure to meet this deadline in excess of a specified percentage of the breakdowns reported is subject to substantial penalty clauses.

In view of this, computer companies have drastically reorganized their repair departments during the past years and, in the process, declared service performance one of the central themes within the organization. In order to meet the strict repair demands, repairing a defective module onsite at the client, if at all technically feasible, is practically always out of the question. This means that a defective module is replaced by a functioning module, and the defective one is taken back for examination and possible repair. This is the only viable way of meeting the strict deadlines. However, this does not mean that the pressure is alleviated. It is true that the engineer need not work under time pressure immediately, but arrangements must be made to ensure that spare modules are in sufficient stock so that the engineers can be supplied with the necessary modules without delay.

The management of such a stock system cannot simply be reduced to a classic stock problem. After all, a characteristic feature here is that each demand for a spare module means that a defective module is offered for repair, which can subsequently be added to the stock of useable modules. The present case thus revolves around the design of an adequate stock control system for repairable parts.

The Service Center of the company *De Betrouwbare Computer* ('The Reliable Computer') is responsible for the management of both repairable parts and modules beyond repair. The warehouse holds a stock of around 10,000 different parts. The non-repairable parts account for around 20% of the total stock volume, whereas the repairable modules account for approximately 80%. The difference in economic value of the two types of stock is even more significant: the non-repairable stock represents a value of approximately EUR 1 million, whereas the repairable stock is worth around EUR 12 million. The non-repairable parts are managed on the basis of a classic stock control system, using exponential smoothing for estimating demand patterns and the EQQ model to generate purchase orders. This system performs satisfactorily. The management of repairable parts is based on a number of rules of thumb, which are applied manually. However, practice shows that these rules are often deviated from and emergency repairs have become daily routine. As such, there is a strong need for automating this stock control system, with a special focus on making the underlying decision rules more explicit.

2 Specific details

Standard stock models are not suitable for managing repairable parts, as the course of the goods flows is rather complex. For instance, there are individual clients without service contracts who directly return and exchange their defective module for a new one. These clients represent approximately 10% of the demand for repairable modules. More than 90% of the demand comes from clients with maintenance contracts, which means, for instance, that they can call the Service Center to report a fault.

The telephones in the Service Center are manned by technical experts who try to obtain, over the phone, as complete a picture as possible of the exact problem. Since the client is often not an expert in the subject matter and can only provide a vague diagnosis, it is often not possible to establish exactly which part is defective over the phone. This means that the engineer who is sent off must take with him multiple parts, to avoid the likelihood of having to return without having accomplished his mission. Therefore, whenever a repair assignment occurs the engineer is generally provided with multiple modules, while ultimately often only one part is replaced at the client. Each night, the transport service furnishes the engineers with the necessary modules to enable them to visit their clients the following day and replace any defective modules. The night transporter who provides the engineers with new modules at the same time collects the defective modules removed by the engineers the previous day and returns them to the Service Center. However, any surplus modules held by the engineers are not returned immediately, but remain in the possession of the engineer for three days. The idea behind this principle is that the engineer may well need the part in the short term, thus preventing an unnecessary “yo-yoing” of modules. However, if a module has not been used in three days, the transporter returns it together with the defective modules, and it is added to the stock of deliverable modules. The defective modules returned to the Service Center are added to the stock of “defective modules”.

Defective modules are always repaired in batches, as this makes optimum use of the repair capacity at the central European workshop. This means that an engineer sometimes spends several days in a row repairing hard disks, followed by a number of days repairing keyboards. Nevertheless, it is possible to perform the repair of a single module of a certain type in-between the scheduled routine work. This possibility for an “emergency repair” is frequently used in the current system. However, the costs involved are fairly high, as an engineer needs a considerable amount of time to switch his focus from one type of module to another. No information is available as to the exact costs thereof, however.

When examining defective modules, it does of course turn out that certain cases are beyond repair. The percentage of non-repairable modules varies from type to type and can vary from 5 to 30%. This means that every now and then a purchase order must be placed in order to keep the volume of modules deliverable from stock at a desirable level. In view of the transport and administration costs, purchases are always made in batches as well.

3 The assignment

A stock control concept must be designed for the management of the Service Center of *De Betrouwbare Computer*, which includes a specific repair and purchasing strategy. The robustness of the proposed strategy must be investigated and a comparison with current practice must demonstrate to what extent the proposed method is preferable to the current practice. The problem in this comparison is that, due to the manual control, currently few performance indicators are available and they are also difficult to generate due to the frequent yet unstructured occurrence of emergency repairs. In terms of performance, the only information available is the percentage of modules that can be delivered immediately, i.e. the percentage of modules that can be delivered to the engineer in the night following the repair request and/or that individual clients can be provided with while waiting. The percentage of modules that can be delivered immediately through emergency repairs is also known. However, the total average costs per time unit involved in the entire service process are less clear.

Provide a complete specification of all data required in order to achieve responsible stock control. Map out a diagram of the goods flow and specify the interaction options in this goods flow. Finally, indicate the assumptions you believe must be made in order to realize an analytical approach (i.e. an approach without simulation) to this problem. At this stage, it may be assumed that the external demand for a module of a certain type can be described by a deterministic and stationary process. A deterministic assumption can also be made for new modules and for the repair times of batches of defective modules.

Obviously, the flow of deliverable modules and that of defective modules are strongly correlated. After all, the defective modules partly feed the flow of deliverable modules, while any request for a new module can result in a repairable module becoming available. Therefore, decisions as to when and how many to repair and how many to order will also be correlated. A decision to start a repair batch can only be made if there is a sufficient stock of repairable items, yet this stock is at the same time reduced by the demand for deliverable items of the relevant type. Therefore, it must first be determined on the basis of what criteria a repair and/or purchase decision should be taken. This process does of course involve multiple choices.

The occurring demand processes are not deterministic in nature. The delivery times of orders of new modules as well as the repair times of batches of defective modules are also based on stochastic variables. A frequently used approach is to declare the strategy developed for deterministic cases (subject to possible corrections) applicable to stochastic cases. The quality of the solution obtained in this way is of course somewhat uncertain, then. Construct a simulation module that can be used to determine the performance of the strategy designed within a stochastic environment.

Once the simulation has established the performance of the strategy, the actual performance level needs to be assessed. After all, the fact that the strategy produces the best possible results in the event of deterministic demand does in itself not say anything about the quality of the strategy within an actual stochastic environment. Since the actual optimum solution is unknown in this case, benchmarking is only possible through comparison with the current situation. As stated previously, key indicators describing the current situation are available to a limited extent only. The available data with respect to one of the repairable modules are provided in the appendix.

A Appendix

The following data for one of the repairable modules are known:

Daily distribution of demand:

Demand	Probability	Demand	Probability
0	0.08	6	0.03
1	0.17	7	0.01
2	0.26	8	0.02
3	0.12	9	0.00
4	0.20	10	0.02
5	0.07	11	0.02

Other data with regard to this module

Fraction of non-repairable modules:	0.05
Fraction of unused modules:	0.33[1]
Time required for a repair batch:	4 or 6 days, 50% chance either way
Delivery times of new module orders:	5 or 10 days, 50% chance either way
Fixed costs in the event of repair batch:	€50
Fixed ordering costs €150	
Stock costs deliverable module:	€0.66 (per unit per day)
Stock costs defective module:	€0.33 (per unit per day)
Percentage delivered from stock:	81.3% (including emergency repairs)
	50% (excluding emergency repairs)
Average number of outstanding backorders	1.01

[1]This means that of every three modules given to the field engineers, one is returned by the engineers after three days (as a surplus item).