A queueing-based optimization model for planning inventory of repaired components in a service center

Paper Summary

It is of no doubt that the continuous advancement in the technological world have had great effect in the rapid globalization of firms focus towards service activities that can better improve customer satisfaction and as well to augment increased and better revenues. To this effect, it has facilitated the view in paradigm shift from product-centric view to user/customer-centric view which has elevated the after-sales service (through service contracts and warranties) from being looked upon as a major part of the firm’s cost to a major source of revenue and profit.

The paper addressed the problem of managing repair capacity and repaired component inventory in a service center. Due to the modular designing of devices nowadays, it makes it easier to troubleshoot and easily find which of the device’s part is faulty and to see and decide if it can be repaired or replaced with another working component. Most of the time, the faulty component is repaired and use to service a future faulty product that arrives for repair.

The inventory problem was modeled as a queueing system with a limit on the queue length and the total cost function involves the steady-state probabilities and the queue length of the queueing system. Optimization algorithms called the “Queueing-based optimization algorithm” for the inventory problem were developed using the property of the cost function derived and identifying the bound on the decision variables.

In order to achieve the goal of solving the problem of the inventory system, they decided to separate the model to be develop into two categories namely: (i) Queueing-based optimization model when all faulty components can be repaired and (ii) Generic queueing-based optimization model when some of the faulty component cannot be repaired. Both models were modeled as M/M/c/K queueing model, and flow-charts of the system was created to show the detailed process of the models and in addition to this, the cost functions were derived separately as the latter model was having a fraction of faulty components that may be beyond repair.

In that case, the underlying queueing model was significantly different when compared to the case where all faulty components can be repaired. The modeling of the service center for the second model is more complex as the sum of the number of faulty components (in queue or in process) to be repaired and the number of the components changed compared to the former model.

Numerical analysis study was carried out comprehensively on the models, the study was aimed at studying the effect of various cost parameters as well as parameters like the arrival rate of faulty components and the percentage of the repairable component on the optimal solution. The numerical result gotten after the analysis indicates that the unit cost of repairing a faulty component (C_r) and the cost of operating a server at the repair center (C_p) play a significant role in the determination of the optimal solution, when the unit cost of manufacturing a new component is fixed.

When both the Cr and the Cp are sufficiently high, the optimal solution is to only use the new component instead of repairing the faulty components but when the Cr and Cp are not high, the optimal solution tries to balance the repair rate with the arrival rate of the faulty components, hence, two strategies were put in place, named; No-Repair strategy (used when Cr and Cp are considerably high) and All-Repair strategy (used when Cr and Cp are considerably low).

In conclusion, the paper considered single-echelon service center, however, in practice, multi-echelon centers are more common. A Continuous-Time Markov Chain, CTMC-based optimization model for multi-echelon service system was proposed as a possible area for future research. They emphasized that the model described in the paper can be extended to Aircraft component repair shops, as in airline industry, the airlines profit depends on the availability of the aircraft, which means that defective components in an aircraft should be repaired or replaced within a very short turnaround time (TAT) for the aircraft to be available for its next flight. They stipulated, however, that this problem is much more complex than what the paper discussed as it involves management of multiple types of components as well as any dependence among the different component types, and hence, makes it an interesting problem for future research.