Optimization of Resource Allocation Using Queueing Theory

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Introduction

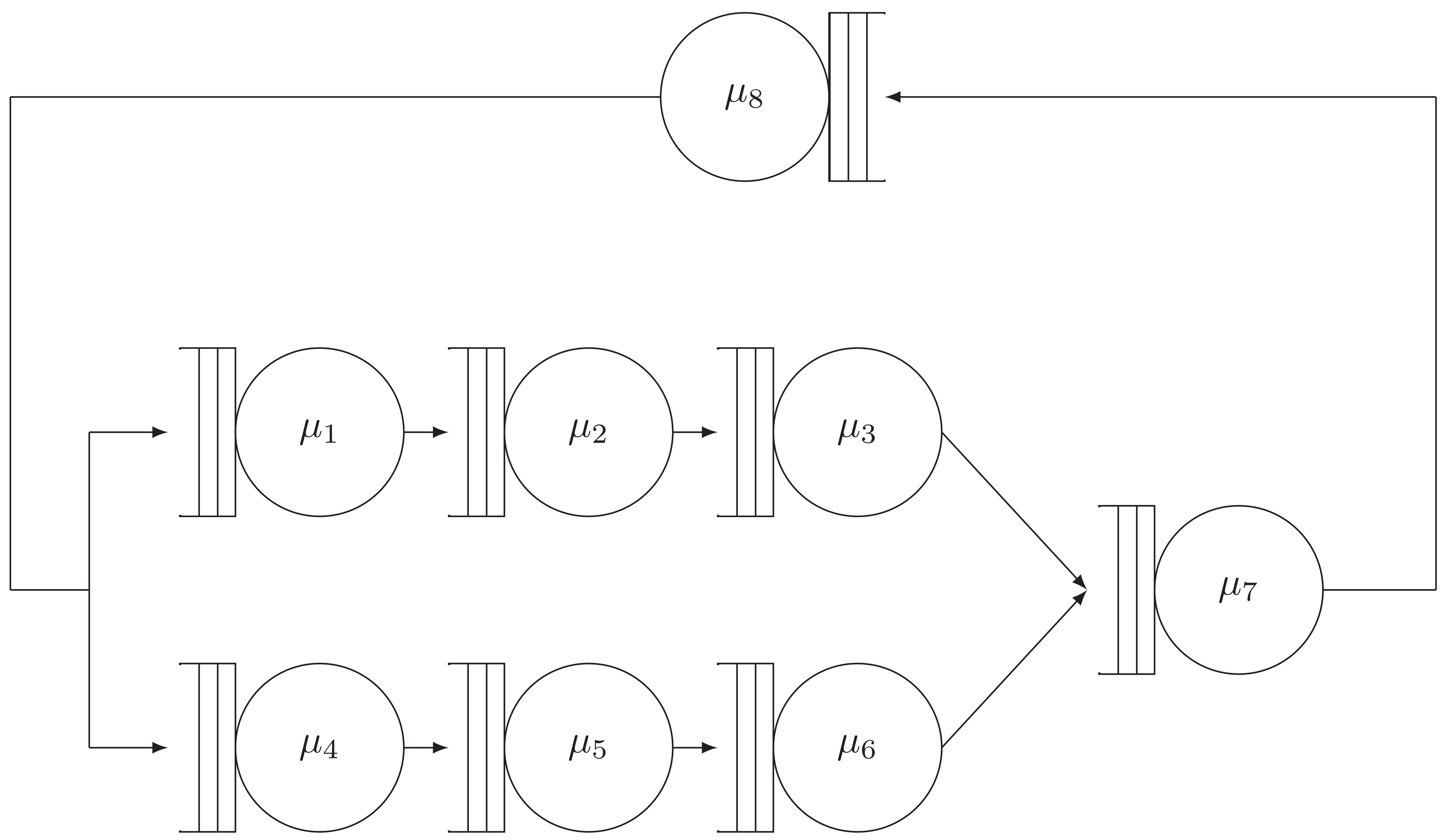
Much of the remaining oil and gas in the world is located in remote areas such as the Barents Sea and the Arctic. It is anticipated that the Arctic will be ice free in summer time in the future. This will open up large areas for oil exploration and later production. These areas are however very remote and far from land, creating long supply chains. Increased supply chain length combined with pressure for lowering the costs requires cost efficient supply chains. As of today, the large oil companies in Norway have their main warehouses located in the south-western part of Norway. Thus, even the first leg of the supply chain which typically goes to Hammerfest is very long. From Hammerfest the sailing time to the installations may be days. In any supply chain there is a cost of providing service, but there is also a cost for not doing so. Downtime or other interruptions in production due to broken equipment or delayed equipment cause huge costs for the companies. The equipment treated in the thesis have a high cost and is critical for the operations. This equipment must be repaired if they break down or recalibrated after use when they are not longer needed on-board the installation. This repair and recalibration usually takes place in one of the main warehouses in southern Norway. These long supply chains will have several echelons where it is possible to store cargo in different warehouses along the chain. Storing the equipment closer to the installation, say in Hammerfest, makes the response time shorter. However, if the equipment is stored in Hammerfest, but suddenly needed in the North Sea, the equipment must be transported south, thus incurring transportation costs. It is therefore important that one stores the equipment optimally.

Objectives

The objective of the thesis was to use queueing theory to determine the optimal allocation of resources, or inventory, to satisfy a given target of operability at the lowest cost. Further, by comparing three supply chain designs presented in *Method and Model* the model seeks to justify the investment in a floating offshore depot vessel.

Method and Model

To model the supply chain, three designs were developed. The fist design consisted of on intermediate warehouse in addition to the main warehouse. This warehouse was called a depot, to emphasize the differences between them, as only the main warehouse was to have repair and recalibration capabilities. This depot was located in Hammerfest, as it already is a depot present there. The second design consisted of one additional depot between the Hammerfest depot and the installation. This depot could either be a self propelled vessel sailing from Hammerfest to a position offshore where it would serve PSVs sailing to the installations. Otherwise, it could be an installation being moored at a fixed location. This depot would then be replenished from the Hammerfest depot. The third design option consisted of large depot vessels sailing from the main warehouse to a position offshore, from where it would service the PSVs in the system. The floating intermediate depot in design number two and the depot vessel in design number three does not exist today, but may be viable solution.



The figure represents the queuing network related to the design solution number one. The circles represent the servers, while the shapes to the left of the circles represent the queues. The arcs between the nodes represent the routing of the system. The installation node is node seven, denoted μ_7. μ_7 equals the arrival frequency of the demand, either due to breakdown of equipment or due to planned operations. This parameter has an exponential distribution with a known mean. When the equipment has been used, it is shipped to the main warehouse with a shipping delay, μ_8. One of the decision variables is the percentage of equipment which can be stored at the main warehouse and the amount that should be stored at the Hammerfest depot. Node 1 represents the main warehouse while node 5 represents the Hammerfest depot. Node 2 represents the transportation time from main warehouse to Hammerfest, while node 3 represents the sailing time from Hammerfest to the installation. Node 2 and 3 equals nodes 4 and 6, respectively. This model layout allows to study the usefulness of having a forward storage.

The objective function tries to minimize the costs of inventory and the costs related to storing them. The service level constraint specifies that a given number of operating and spare parts should be present at the installation for a given percentage of the time. Using the decision variables as input, a queueing algorithm called Buzen's algorithm ensured the feasibility of the solution. The optimization was performed using the Genetic Algorithm in Matlab.

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Results and Conclusion

The results are not complete at the moment, so no clear conclusion has been made yet. However, the model can determine minimum required number of equipment in the network, but struggles to allocate them between the warehouses. To overcome this problem, discrete event simulation should be considered and is likely a better approach.