Title: Control of A Two-stage Queueing Network for the Planning of Outfitting Processes in Shipbuilding

Keywords:

Planning and Control, Queueing Network, CONWIP, Simulation, Outfitting in Shipbuilding.

Abstract:

As an important part of shipbuilding, outfitting refers to the process of fabrication and installation of non-structural components, including main propulsion system, pumps and piping system, electrical system, air conditioning (HVAC), and so forth. In many instances, outfitting represents as much as 50% of the cost of the ship and also as much as 50% ship construction time. However, due to the disturbances by unexpected delays, system variations, capacity limitations, and technological constraints, scheduling of outfitting processes is therefore complex and always being delayed. To improve the shipbuilding system efficiency and reduce the cost, an effective work plan and control for outfitting processes is developed in this paper.

The particular problem addressed in the paper is that when (or at which stage) the outfitting work for each block should be processed during the ship construction. The number of stages in ship production is simplified into two in this study. Stage 1 is all the processes of ship construction before the final hull construction in the dry dock, including steel fabrication and block assembly. Stage 2 is the process of final hull construction in the dry dock. Two models are developed for both strategic level and execution level. A two-stage static model is formulated for strategic level (see Figure 1). A closed two-stage controlled queueing network is simulated for the execution level.

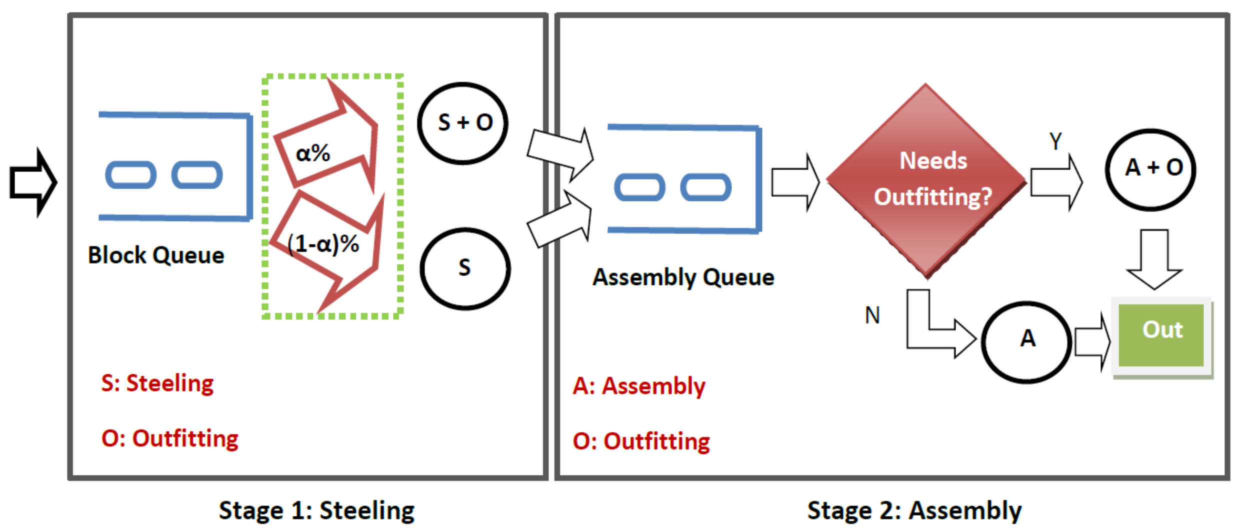

Figure 1. Strategic Model

In the static model (see Figure 1), there are three tasks: steel work (S), final assembly work (A), and outfitting work (O). Task S can be only processed at stage 1 and task A can be only processed at stage 2. Task O can be either processed at stage 1 or stage 2. There is an i.i.d. sequence of Bernoulli (α) trials (independent of all else) randomly selecting the task O to be performed at stage 1 or stage 2. Assume infinite buffers each stage and α does not change over time. The arrival process of blocks to stage 1 has a constant rage of λ and an inter-arrival time CV denoted C_{a1}. The processing time of task S, A, O are generally distributed. The objective of the model is to find the optimal α to maximize the system throughput. From the strategic planning perspective, this model will provide the information of the best percentage of outfitting work should be done before the final hull construction.

Although the static model provides the value of percentage of outfitting work should be done before the final hull construction for the entire ship, it is still unknown for when to do outfitting for each block in execution level. Therefore, a closed two-stage controlled queueing network is developed for simulation. Similar to the static model, there are still three task: S, A, and O. In stage 1, instead of Bernoulli trials, it can be controlled whether to do outfitting or not, based on the system dynamic. Several heuristic control policies will be applied in simulation, including Longest Queue policy, Threshold policy, and Strict Priority policy. Block assembly sequence can be also added to the simulation as one constraint. The performance of each control policy by simulation will be compared to the optimal percentage α from static allocation model. This dynamic queueing model will provide an efficient control policy for doing outfitting to each block given different circumstances.

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