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# Business process management-based job assignment in ship hull production design

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ABSTRACT

As a part of the IT convergence in the shipbuilding industry, we examine the adoption of business process management (BPM) for the ship hull production design process. Ship hull production design, which is a process-based task, requires the most man-hours (M/H) among all ship design processes and is directly coupled with ship production, whereby improvements in this task can provide large contributions to enhancing productivity. Thus, we analyze the hull production design task from the perspective of the business process to generate BPM models for a manager and design engineers. Particularly for the manager process, we implement the optimal assignment method as a part of the decision support system to help the manager efficiently assign hull blocks to design engineers in the BPM system (BPMS). In this paper, we suggest the concepts of the block standard design M/H and variable design M/H for the assignment problem. We compute the estimated M/H by using models developed after this concept. To minimize the total required M/H of assignments for the production design, we adopt the Hungarian algorithm. The BPM executable model of the hull production design process is implemented using Bonita Open-Solution 5.7, which is a representative open-source BPMS.


## 1. Introduction

In this study, we analyze a ship hull production design process to implement a design manager process to handle job assignment problems using a business process management system (BPMS). As an introduction to the research topic, we briefly introduce business process management (BPM) and the shipbuilding process.

### 1.1. Business process management

After the adaptation of the workflow as an approach to grasp and execute works from the perspective of a process, BPM was introduced with the intent of achieving the continuous monitoring and improvement of a process through the closed loop of "plan-do-check-act," including the complete roles of a workflow (WfMC-TC-00-1003, 1995; WfMC-TC-1011,1999; WfMC-TC-1016-P, 1999; Aalst et al., 2000; Smith and Fingar, 2003). In other words, as shown in Fig. 1, workflow is an approach to grasp and execute works from the perspective of a process so that the process can be defined by a developer and used by a user in a certain workflow system. BPM includes the workflow, which models, manages, and executes the process, and has additional functionalities such as the real-time monitoring, the process improvement through the analysis of logs, and the work improvement through a simulation so that in this paper, we use BPM as a technique to manage a process-based work.

After a domain expert captures the corresponding work in the form of a process, a process modeler converts this into the BPM model for execution in a BPMS (Lee, 2010). A BPMS engine assigns the implemented BPM process model to an end-user of the BPMS, who is also in charge of the corresponding work in the real business world, to create a process instance. Whenever a participant starts and completes a task, the BPMS engine carries out the tasks automatically according to the process. These kinds of process instances can exist for several participants, and a single participant can have multiple process instances at the same time. Even within a single process, participants can be different for each task. This is demonstrated by the approval process: this process is accomplished when different participants confirm in sequential order (e.g., staff, assistant manager, manager, and director). When BPM is adopted, not only process execution and management using BPMS but also other functionalities are

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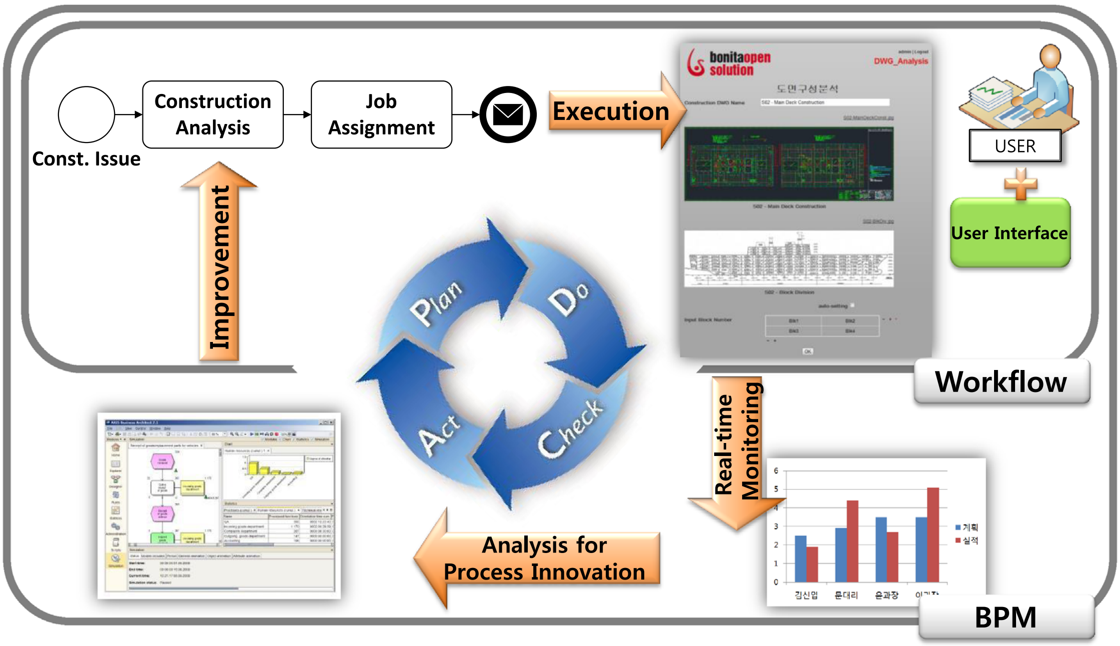


**Fig. 1.** Relation between the workflow and the BPM.

possible; these include business activity monitoring (BAM) for grasping work progress in an instant and rescheduling of job assignments or load balancing during run-time, the rearrangement and optimization of the process definition model (PDM) during build-time, and business process reengineering (BPR) to improve the business process itself after log analysis for certain periods of time (Lee et al., 2010).

### 1.2. Shipbuilding process

When a ship is ordered, the following processes are necessary for building a ship in a shipyard: basic design, detail design, fabrication including steel cutting, assembly, erection, launch, trial test, and delivery (Lamb, 2003; Storch et al., 2007). The basic design process is already sufficiently covered academically in undergraduate courses on naval architecture and ocean engineering (Zubaly, 1996; Tupper and Rawson, 2001, Watson, 2002; Tupper, 2005). Because a hull detail design is performed for each major compartment of a ship according to strength calculations based on structural analysis of the whole ship and local structures (Hughes and Paik, 2010), it is single task-level work rather than process-based work. Hull production design is a final-stage design and acts as a bridge between design and production. Hull production design is closely related to the facilities and production processes of an individual shipyard as the design standards and methods differ from one shipyard to another. Because the design standards and methods are given in the form of a shipyard work manual and engineering calculations are not required for the design, hull production has rarely been analyzed and studied academically. Compared to basic design and detail design, the hull production design process requires more man-hours and output to complete; thus, this area is expected to show the most business improvements and productivity gains when approached from the perspective of a business process.

### 1.3. Related works

There have been many studies based on detail analysis of the shipbuilding design process. Bronsart et al. (2005) developed the model of communications required for the ship design process to set up an environment for seamless collaboration. Kim et al. (2002) analyzed the shipbuilding process from design to production to implement a simulation model for simulation-based design (SBD) and digital manufacturing. Wu and Shaw (2011) analyzed the ship basic design process from the perspective of the workflow and applied this to set up the knowledge-based engineering (KBE) system. Yang et al. (2012) and Cui and Wang (2013) studied the ship structural design process and applied KBE to structural design and optimization. Hiekata et al. (2007b) suggested an educational framework for the ship basic design process based on Tribon M3 using ShareFast, which is a semantic web-based e-learning system. Hiekata et al. (2007a) also analyzed and approached the ship basic design process in terms of the workflow to implement an executable workflow model using ShareFast. Ze et al. (2005) suggested a process model based on analysis of the shipbuilding process from the perspective of collaboration design.

In addition to these academic approaches, there have been some attempts to adopt the workflow system or BPMS for the design process in shipyards, but all were applied to initial ship design phases such as basic design or hull structure design (Astrup and Wøien, 2006; Park et al., 2007; Jang et al., 2010). To the best of our knowledge, no studies have analyzed and presented a ship hull production design process from the perspective of the workflow; thus, this is one of the original contributions of the present research.

The classical assignment problem (AP) deals with the question of how to assign m agents (or machines) to be assigned to m tasks (or jobs) (Burkard et al., 2009). There can be various combinations of assignments however when there is an objective such as maximization of efficiency or minimization of cost, it becomes a combinational optimization problem. Hungarian algorithm is one that solves the combinational optimization problem in polynomial time (Kuhn, 1955). The Hungarian algorithm was developed and present by Kuhn in 1955; it is a combinational optimization algorithm that can solve an AP in polynomial time (Burkard et al., 2009). Furthermore, Munkres (1957) improved this method to solve an AP in the execution time of $O(n^3)$. The Hungarian algorithm has been widely applied in various industries to solve APs: for example, target assignment research for an unmanned aerial vehicle (UAV) (Turra et al., 2004; Shima et al., 2006), job