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Development of IOT-based Reconfigurable Manufacturing System to solve Reconfiguration Planning Problem

Kezia Amanda Kurniadi[a], Kwangyeol Ryu[a,]*

[a]*Pusan National University, Busan 609-735, South Korea*

Abstract

Reconfigurable Manufacturing System (RMS) appeared as a solution to high variation in customer demands allowing manufacturers to satisfy different amount of demands in each single period. In RMS, the system satisfies demands by reconfiguring the machines exactly when and where needed by adding and removing machines whose number depends on the demand of every single period. The reconfiguration process brings a critical issue within the RMS that is called as reconfiguration planning (RP) problems in this paper. However, with the rise of Internet of Things (IoT) that has been a global issue, many companies or manufacturers are trying to integrate it into their smart systems. RMS as well needs to apply IoT in order to establish the internetworking between machines and the logic, so that RP problems can be solved, automated, and controlled. This paper addresses the importance of the integration of IoT into RMS and the development of mathematical model to solve RP problems in order to save reconfiguration time, cost, and effort. The contribution of the proposed idea is evaluated by using simulation software.

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Keywords: Reconfigurable manufacturing system ; Reconfigurable manufacturing tools ; Internet of Things ; Simulation

* Corresponding author. Tel.: +82-51-510-2473; fax: +82-51-512-7603.
E-mail address: kyryu@pusan.ac.kr

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1. Introduction

Manufacturing systems have rapidly evolved driven by aggressive competition on a global scale and customers who are more educated and demanding, causing a quick pace of change in product and process technology. Reconfigurable manufacturing system (RMS) is a recent manufacturing paradigm where machine components, machines, cells, or material handling units can be added, removed, modified, or interchanged as needed to respond quickly to changing requirements. Such a fully reconfigurable system does not yet exist, but it is the subject of active research efforts. In summary, an ideal RMS comprehends the advances of Dedicated Manufacturing System (DMS) and Flexible Manufacturing System (FMS) [1]. RMS is marked by six core reconfigurable characteristics, such as customization, convertability, scalability, modularity, integrability, and diagnosability [2].

The process of RMS requires adding and removing machines with exact number to meet the demands. Demands that periodically change also cause the machines reconfigurations. The changes of machine reconfigurations in RMS are evoked by influencing factors, to new conditions by adapting the set of machines, as known as configurations in RMS. Hence, these reconfigurations are always connected to monetary and temporal expenses. Reflecting at those conditions, the systematic and organized planning is very necessary in RMS, whether to minimize cost or/and save time and energy.

However, to comply with the recent global needs of internet-integrated networks, there said to be an urgent need of the application of Internet of Things (IoT) into the system of global companies and manufacturers [3,4]. By connecting machines, manufacturers can create intelligent networks along the entire value chain that communicate and control each other autonomously. This technology is able to deliver dynamic, efficient, and automated manufacturing processes. Actualization of the IoT concept into the real world is possible through the integration of several enabling technologies, such as RFID systems [5], which are composed of one or more reader(s) and several RFID tags. Accordingly, RFID systems can be used to monitor objects in real-time, without the need of being in line-of-sight; this allows for mapping the real world into the virtual world. Therefore, they can be used in an incredibly wide range of application scenarios, spanning from logistics to e-health and security.

The IoT is the interconnection of physical objects, by equipping them with sensors, actuators, and means to connect to the internet [6]. Factories or plants that are connected to the Internet are more efficient, productive and smarter than their non-connected counterparts [7]. Especially, in RMS, reconfiguration of Reconfigurable Machine Tools (RMT) requires quite amount of time to setup or rearrange the layout, sometimes even shutdown of the whole production process. By technologically enabling IoT, the goal is to develop new implications and to improve existing applications of RMS. And a more optimal reconfiguration time, process, and productivity can be achieved.

Therefore, the purpose of this research is firstly to introduce an IoT-based RMS and reconfiguration planning (RP) problem in RMS. The second purpose is to design a mathematical model in order to minimize the cost of adding/removing machines and the cost of machine reconfiguration. This problem is to make sure that RMS is able to save more resources and costs. Then, a simulation model is built by using Plant Simulation software for the decision of machine reconfiguration while minimizing the cost. In this study, manufacturing process for making flip-flop is used as a case study. After experimentation of simulation model, the results will be analyzed to carry out the main objectives of the study.

2. Framework of IoT-based RMS

RMS is a multi-stage manufacturing system which can allow for several configurations, depending on how the machines are arranged in each stage [8]. Demand of production will vary from period to period. There can be more than one type of machines to be bought, selected, and used to satisfy the demand, with various different specifications for each machine. First of all we should define different steps of reconfiguration and then deal with the problem of ease/difficulty of the reconfiguration.

Step 1: We define the requirement of process in this step.

Step 2: We generate possible different configurations that fulfill the requirement defined in step 1.

Step 3: In this step the evaluation of the configurations done and we eliminate infeasible configurations.