A Banker's Solution for Deadlock Avoidance in FMS With Flexible Routing and Multiresource States

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Report

This paper presents an extension of the classical Banker's algorithm to a class of flexible manufacturing systems modeled by means of Petri nets. The Banker algorithm, sometimes referred to as the detection algorithm, is a resource allocation and deadlock avoidance algorithm that tests for safety by simulating the allocation of predetermined maximum possible amounts of all resources, and then makes an "s-state" check to test for possible deadlock conditions for all other pending activities, before deciding whether allocation should be allowed to continue. A flexible manufacturing system is a manufacturing system in which there is some amount of flexibility that allows the system to react in case of changes, whether predicted or unpredicted. In these systems, flexible routing of parts is allowed, and also a multiset of resources is allowed to be used at each processing step.

In this paper, concept of maximum needs for a whole process is converted into the concept of requirements for a process to terminate from the current state. The paper introduces a class of Petri nets, named S* P R , able to deal with sequential Reliability, availability and serviceability (RAS) with routing flexibility and the use of multiple copies of different resources per state. The proposed deadlock avoidance algorithm is applicable for RAS with controlled transitions related to granting of resources, and for which the set of states a part can stay in during its processing in the system is known. These states and their changes can be modeled by means of a state machine, so that any cycle containing the initial state is a correct production sequence for the given type of part. Moreover, all the paths joining a given state and the initial state are "equivalent," in the sense that any of them is a valid alternative to terminate the processing of any part in the considered state.

The first main contribution of this paper is the definition of a class of Petri nets, called S* P R , which is able to model a wide set of manufacturing systems and is a natural addition of previous classes of nets used in the literature. These nets model RAS with routing flexibility in the processing of parts and multiset of resources at each processing step of a part. The other main contribution is the introduction of a Banker's-like algorithm for deadlock avoidance in S* P R nets. The cost of applying the algorithm to decide whether a state is safe (and then, to ensure that all the in-process parts can be terminated) is polynomial in the model size. Further improvements include looking for more permissive and efficient avoidance policies, the concept of "zone", or the concept of "control point".