On Intrinsically Live Structure and Deadlock Control of Generalized Petri nets modeling Flexible Manufacturing Systems

Mots clés :

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- Domaine scientifique principal: Divers

Résumé du projet de recherche (Langue 1)

As an indispensable component of contemporary advanced manufacturing systems, flexible manufacturing systems (FMSs) possess flexibility and agility that traditional manufacturing systems lack. An FMS usually consists of picking and placing robots, machining centers, logistic systems, and advanced control systems. Some of them can be recognized as its shared resources, which are the root of flexibility and deadlocks. As a classic problem in resource allocation systems, deadlocks may arise in a fully automated FMS and bring about a series of disturbing issues, from degraded and deteriorated system productivity and performance to low utilization of some critical and expensive resources and even long system downtime. Therefore, an analysis and solution to deadlock problems are imperative for both a theoretical investigation and practical application of FMSs. Deadlock-freeness means that one or more concurrent production processes in an FMS will never stagnate. Furthermore, liveness, another significant behavioral property, means that every production process can always be finished. Liveness implies deadlock-freeness, but not vice versa. The liveness-enforcement is a higher requirement than deadlock-freeness. From the perspective of the behavioral logic, the thesis focuses on the intrinsically live structures and deadlock control of generalized Petri nets modeling flexible manufacturing systems. Being different from the existing siphon-based methods, a concept of intrinsically live structures becomes the starting point to design, analyze, and optimize a series of novel deadlock control and liveness-enforcing methods in the work. The characteristics and essence of intrinsically live structures are identified and derived from subclasses of generalized Petri nets modeling FMSs with complex resource usage styles. Additionally, the numerical relationship between initial markings and weights of connecting arcs is investigated and used to design restrictions that ensure the intrinsical liveness of global or local structures. With the structural theory, graph theory, and number theory, the work in the thesis achieves the goals of deadlock control and liveness-enforcement superior over the traditional siphon-based ones with a lower computational complexity (or a higher computational efficiency), a lower structural complexity, or a better behavioral permissiveness of the controlled system.