Corrections to "Deadlock Prevention for a Class of Petri Nets With Uncontrollable and Unobservable Transitions"

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In the above paper [8, p. 733], there are errors in Theorem 1:

Theorem 1 [8]: Suppose that $L^*M \geq 1$ is the liveness constraint of siphon S in an LS^{3}PR. The monitor enforcing $L^*M \geq 1$ exists iff the following four conditions are satisfied.

1) $\forall t \in T_S^-$ and $\forall t_{so} \in T_t$, $T_{t_{so}-t} \cap T_o \neq \emptyset$.
2) $\forall t' \in T_S^+$, $T_{t'-t_{si}} \cap T_o \neq \emptyset$, where t_{si} is the sink transition of t'.
3) $\forall t' \in T_S^+$, if $\exists p \in P_{bs}$ such that $T_{t'-p} \cap T_o = \emptyset$, then $\forall t^* \in ({}^\bullet p \cap T_{uo}) \backslash T_{t'-p}$ and $\forall t_{so} \in T_{t^*}$, $T_{t_{so}-t^*} \cap T_o \neq \emptyset$.
4) $\forall t \in T_Y \cap V_S^\bullet$ and $\forall t_{so} \in T_t$, $T_{t_{so}-t} \cap T_c \neq \emptyset$.

It should be revised as follows:

Theorem 1: Suppose that $L^*M \geq 1$ is the liveness constraint of siphon S in an LS^{3}PR. The monitor enforcing $L^*M \geq 1$ exists if the following four conditions are satisfied.

1) $\forall t \in T_S^-$, $\forall t_{so} \in T_t$, $T_{t_{so}-t} \cap T_o \neq \emptyset$.
2) $\forall t' \in T_S^+$, $T_{t'-t_{si}} \cap T_o \neq \emptyset$, where t_{si} is the sink transition of t'.
3) $\forall t' \in T_S^+$, if $\exists p \in P_{bs}$ such that $T_{t'-p} \cap T_o = \emptyset$, then $\forall t^* \in ({}^\bullet p \cap T_{uo}) \backslash T_{t'-p}$, $\forall t_{so} \in T_{t^*}$, $T_{t_{so}-t^*} \cap T_o \neq \emptyset$.
4) $\forall t \in T_Y \cap V_S^\bullet$, $\forall t_{so} \in T_t$, $T_{t_{so}-t} \cap T_c \neq \emptyset$.

The conditions of the existence of a monitor to enforce a liveness constraint are claimed to be sufficient and necessary in [8, Th. 1]. However, they are sufficient but unnecessary. The flaw is caused by ignoring the existence of spurious markings [1]–[3] in Theorem 1, Condition (4) in [8]. It gives a condition about T_Y which is derived from Definitions 11 and 13 by searching the state space derived from the state equation of a Petri net under consideration. As is known, the state space derived from the state equation contains two kinds of markings: reachable markings and spurious ones while the reachability space contains only reachable ones, as shown in Fig. 1.

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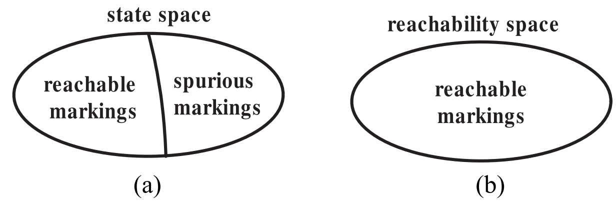

Fig. 1. (a) State space. (b) Reachability space.

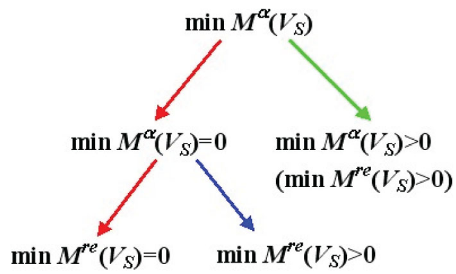

Fig. 2. Computation of min $M^{re}(V_S)$ and min $M^\alpha(V_S)$.

In Definition 11 [8], min $M^\alpha(V_S)$ is obtained by searching the state space. Let min $M^{re}(V_S)$ denote the minimum of $M^{re}(V_S)$ with $M^{re}(p) \geq 1, \forall p \in {}^\bullet t \cap (P_A \cup P_R \cup P^0)$, which is obtained by searching the reachability space. Since the reachability space is the subspace of the state space, we have min $M^{re}(V_S) \geq$ min $M^\alpha(V_S)$. Then, there are two results: 1) min $M^\alpha(V_S) > 0$ and 2) min $M^\alpha(V_S) = 0$ as shown in Fig. 2. For min $M^\alpha(V_S) > 0$, it implies that min $M^{re}(V_S) > 0$, which means that a transition is secure with respect to V_S. If the transition is secure with respect to each of its input monitor, it is fully secure. Since min $M^{re}(V_S) \geq$ min $M^\alpha(V_S) > 0$, a fully secure transition determined by Definitions 11 and 12 is secure in fact.

For an input monitor V_S of an uncontrollable transition t, if min $M^\alpha(V_S) = 0$, t is called risky from Definitions 11 and 13. In this case, we have: 1) min $M^{re}(V_S) = 0$ and 2) min $M^{re}(V_S) > 0$ as shown in Fig. 2. min $M^{re}(V_S) = 0$ indicates that the transition is risky while min $M^{re}(V_S) > 0$ means that the transition is secure in fact. It indicates that min $M^\alpha(V_S) = 0$ with min $M^{re}(V_S) > 0$ is caused by the existence of spurious markings. If min $M^\alpha(V_S) = 0$ and min $M^{re}(V_S) > 0$ are true for each input monitor of a risky transition t, it is fully secure. Therefore, the risky transitions obtained from the state space may contain some transitions that are fully secure in the reachability space.

Since Condition (4) in Theorem 1 in [8] deals with each risky transition in the state space, min $M^\alpha(V_S) = 0$ and min $M^{re}(V_S) > 0$ are a special case that is not considered. The condition deals with each risky transition in the state space, some of which may be fully secure in the reachability space. It is unnecessary to deal with fully secure transitions. Therefore, Condition (4) in Theorem 1 in [8] is sufficient but unnecessary. As a result, if we can delete these fully secure transitions in the reachability space from T_Y that is the set of uncontrollable and risky transitions, Condition (4) is necessary. However, it will be considered in the future work by combing siphons and their controllability [4]–[7] to further simplify the conditions in Theorem 1 in [8]. It is also interesting to explore the condition under which there exists a maximally permissive supervisor for an LS^3PR with uncontrollable and risky transitions by a set classification approach [9] and structural analysis.

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