Deadlock Avoidance of Flexible Manufacturing Systems by Colored Resource-Oriented Petri Nets With Novel Colored Capacity

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Overview

CROPN

Creator

The concept of colored resource-oriented petri nets (CROPN) is proposed by Professor Wu's work.

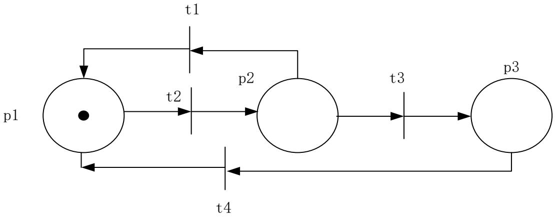
feature 1

resource-oriented modeling method

feature 2

colors and capacity

CROPN modeling method



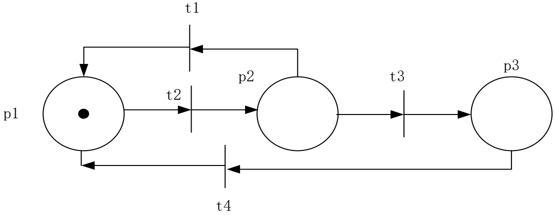
process plan

Part types A and B. Plane for $A : r_1 \rightarrow r_2$. Plane for $B : r_1 \rightarrow r_2 \rightarrow r_3$

resource-oriented

place p_1 for r_1, p_2 for r_2, and p_3 for r_3.

CROPN color



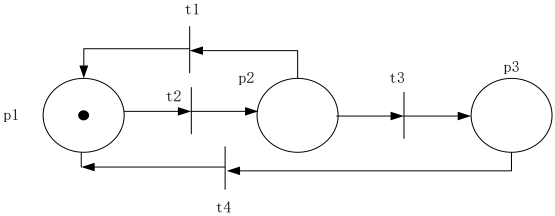
color

Token with color $t_i \in T$ can only enable transition t_i.

notation

We use $M(p, t)$ to represent the number of tokens with color t in place p at marking M.

CROPN color assumption



Remark

The work in Professor Wu assume that the color of a token will changed when this token goes from a place to another and the change of color is decided by a process plan and is known in advance.

For instance, for part $B: p_1 \to p_2 \to p_3$: token$(p_1, t_2) \to$ token $(p_2, t_3) \to$ token (p_3, t_4).

CROPN capacity

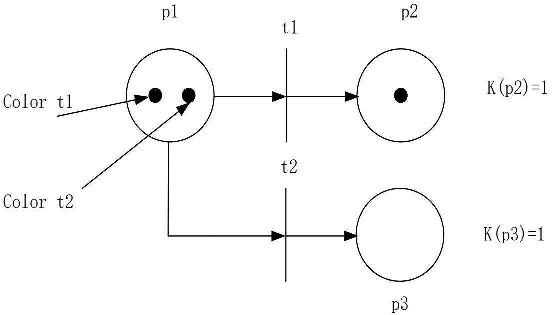


Figure: A simple example for illustration

capacity

We use $K(p)$ to denote the number of tokens the place p can hold.

CROPN

Control policy

To forbid bad markings.

Realization

To add control places to the net

Ideal of this paper

We introduce color into capacity and define the colored capacity to realize the given control policy without adding control places.

Colored capacity

Feature

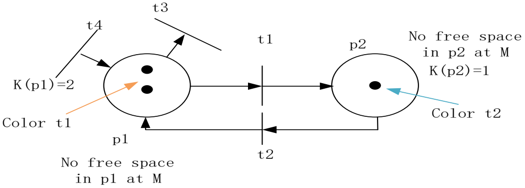
We introduce color into capacity. Then we can restrict number of token with specific color in a place.

Colored capacity

Given a CROPN with marking M, let $K_c : P \times T \times M \to \{0, 1, \dots\}$ be the colored capacity such that for all $p \in P$, for all $t \in T$, for all marking M reachable from the initial marking, $K_c(p, t, M)$ represents the maximum free number of tokens with color t that p can hold at marking M.

For instance, if we set $K_c(p_1, t_1, M) = 1$, then the free space for token with color t_1 is one in place p_1 at marking M.

CROPN control policy



Setting

$t_1 \rightarrow$ token with color t_3 or t_1 in place p_1. $K(p_1) = 2, K(p_2) = 1$.

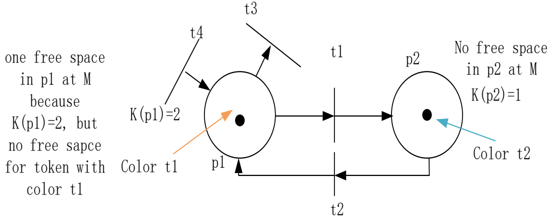
bad marking

$M(p_1, t_1) = 2$ and $M(p_2, t_2) = 1$.

control policy

$u_1 : M(p_1, t_1) + M(p_2, t_2) \leq 2$.

CROPN



Control policy to be realized

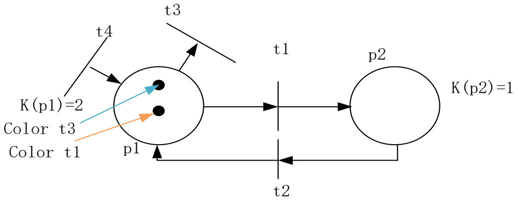
$u_1 : M(p_1, t_1) + M(p_2, t_2) \leq 2.$

Colored capacity

$K_c(p_1, t_1, M) = 2 - M(p_1, t_1) - M(p_2, t_2).$

If $M(p_1, t_1) = 1$ and $M(p_2, t_2) = 1$, then we have $K_c(p_1, t_1, M) = 0$.

Realization of control policy by colored capacity



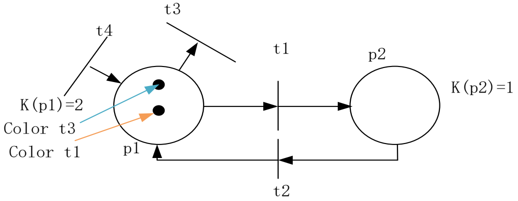
Colored capacity

$K_c(p_1, t_1, M) = 2 - M(p_1, t_1) - M(p_2, t_2).$

Contradiction

$M(p_1, t_3) = 1$ and $M(p_1, t_1) = 1, M(p_2, t_2) = 0$, then we have $K_c(p_1, t_1, M) = 1$, which contradicts $K(p_1) = 2$.

Realization of control policy by colored capacity



Colored capacity

$K_c(p_1, t_1, M) =$
$min[(2 - M(p_1, t_1) - M(p_2, t_2)), K(p_1) - M(p_1, t_1) - M(p_1, t_3)]$

Thus if $M(p_1, t_3) = 1$ and $M(p_1, t_1) = 1, M(p_2, t_2) = 0$, we have $K_c(p_1, t_1, M) = 0$. Then we solve the contradiction above.

Conclusion

Remark 1

We do not consider how to obtain control policies.

Remark 1

Colored capacity is marking-variant.

Remark 2

Normal capacity:no color. Colored capacity:have color.

Contribution of this paper

We introduce color into capacity and define the colored capacity to realize the given control policy without adding control places.

Thanks