行政院國家科學委員會專題研究計畫 成果報告

S3PR 的 N-依賴虹吸管的可控性
研究成果報告(精簡版)

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 100-2221-E-004-001-
執 行 期 間 ：100 年 08 月 01 日至 101 年 07 月 31 日
執 行 單 位 ：國立政治大學資訊管理學系

計 畫 主 持 人 ：趙玉

計畫參與人員：此計畫無其他參與人員

公 開 資 訊 ：本計畫可公開查詢

中 華 民 國 101 年 09 月 16 日

中 文 摘 要 ： 鎖死停止自動化系統對公司造成重大的財政損失。 學界使用派翠網路把
所有狀態找出(由狀態樹)便能找出死鎖原因。狀態樹可分為好和壞兩區
域，壞區域又可分為危險和死鎖區。一旦進入危險區，便無可避免地走向
死鎖區。死鎖防治是目前普遍採用方法，加控制器以防止系統進入危險區。
主要是防治首次會見壞標記（First-met Bad Marking, FBM）的發生，以
減少控制器數目。最大許可和使用最少監控的最佳合成控制器一直是一個
熱門的課題。同時記憶體及 CPU 的使用量也要越少越好。
目前所有最大許可的死鎖防止方法都須依靠狀態樹來列舉所有的狀態
或混合整數規劃（MIP）測試。這隨著派翠網路大小迅速(稱為指數型態)往
上爆升而超過電腦所能承擔。因此此類方法無法處理大型網路。其他方法
亦有類似問題。
本人提議革命性的控制理論以線性複雜度找出所有基本虹吸，進而以
最少的控制器達到最大允許狀態，且能避免電腦難以處理的指數型態(避
免狀態樹建立）。
目前本人已發展理論，找出由 N 個基本虹吸複合成區域死鎖所有標記
(Marking) 狀態。從而據此加入控制器。進一步，結合數個控制器，以減
少控制器，並達到最大允許狀態。
本人提議結合上述理論，直接由 N 個基本虹吸複合推導出最少控制器最
大允許，而無須找出死鎖所有標記及結合數個控制器之部驟。
這項建議達到最佳，並導致我們在該領域領先的學術地位。
它可以控制實時和在線時的大型網路。

中文關鍵詞： —派翠網，信標可控性，FMS，S3PR，死鎖，控制。

英 文 摘 要 ： Deadlocks halting automated systems cause significant financial loss. Scholars use Petri nets to find all the states (by the state tree) are able to identify

the cause of deadlocks. State tree can be divided into two areas of good and bad. Once inside the danger zone, it will inevitably evolve towards deadlock area. Deadlock prevention is commonly used methods by adding the controller to prevent the system from entering the danger zone. It has been a hot research to synthesize optimal controllers to be maximally permissive with fewest monitors. Both memory and CPU usage should be as minimal as possible. At present, all the maximally permissive methods rely on state tree to enumerate all of the states or mixed integer programming (MIP) test. The number of states or iterations grows exponentially with respect to the size of a Petri net. Therefore, such methods cannot handle large nets.
I propose a revolutionary fastest maximally permissive control theory to find all the basic siphons with linear complexity and least number of controllers, and there is no need to construct reachability tree. The complexity of the policy is no longer exponential.
Currently I have developed theories to identify unmarked token patterns of local blockings for a N-compound region consisting N basic siphons. Furthermore, a method is developed to combine some of these controllers to reduce the number of controllers while achieving maximal permissiveness.
I propose to combine these theories to directly find the above final set of controllers based on set of the basic siphons without the need to identify all emptiable siphons and the associated unmarked token patterns to lead to local blockings.

This proposal achieves the best in the field and leads us to the leading academic position. It allows to control large net in real time and online fashion.

英文關鍵詞： Petri nets, siphons, deadlocks, control.

行政院國家科學委員會補助專題研究計畫成果報告

S3PR 的 N-依賴虹吸管的可控性

計畫類別：■個別型計畫　　□整合型計畫

計畫編號：**100-2221-E-004-001-**

執行期間：　**100** 年 **8** 月　**1** 日 至 **101**　年 **7**　月 **30** 日

計畫主持人：趙玉

共同主持人：

計畫參與人員：

執行單位：政治大學資管系

中　華　民　國　　100　年　9　月　14　日

行政院國家科學委員會專題研究計畫成果報告

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共 同 主 持 人：
計畫參與人員：

一、中文摘要

鎖死停止自動化系統對公司造成重大的財政損失。學界使用派翠網路把所有狀態找出(由狀態樹)便能找出死鎖原因。狀態樹可分為好和壞兩區域，壞區域又可分為危險和死鎖區。一旦進入危險區，便無可避免地走向死鎖區。死鎖防治是目前普遍採用方法，加控制器以防止系統進入危險區。主要是防治首次會見壞標記（First-met Bad Marking, FBM）的發生，以減少控制器數目。最大許可和使用最少監控的最佳合成控制器一直是一個熱門的課題。同時記憶體及CPU 的使用量也要越少越好。目前所有最大許可的死鎖防止方法都須依靠狀態樹來列舉所有的狀態或混合整數規劃（MIP）測試。這隨著派翠網路大小迅速(稱為指數型態)往上爆升而超過電腦所能承擔。因此此類方法無法處理大型網路。其他方法亦有類似問題。本人提議革命性的控制理論以線性複雜度找出所有基本虹吸，進而以最少的控制器達到最大允許狀態，且能避免電腦難以處理的指數型態(避免狀態樹建立）。目前本人已發展理論，找出由N 個基本虹吸複合成區域死鎖所有標記（Marking）狀態。從而據此加入控制器。進一步，結合數個控制器，以減少控制器，並達到最大允許狀態。本人提議結合上述理論，直接由N 個基本虹吸複合推導出最少控制器最大允許，而無須找出死鎖所有標記及結合數個控制器之部驟。這項建議達到最佳，並導致我們在該領域領先的學術地位。它可以控制實時和在線時的大型網路。

關鍵詞: 派翠網，信標可控性，FMS，S3PR，死鎖，控制。

Abstract

Deadlocks halting automated systems cause significant financial loss. Scholars use Petri nets to find all the states (by the state tree) are able to identify the cause of deadlocks. State tree can be divided into two areas of good and bad. Once inside the danger zone, it will inevitably evolve towards deadlock area. Deadlock prevention is commonly used methods by adding the controller to prevent the system from entering the danger zone. It has been a hot research to synthesize optimal controllers to be maximally permissive with fewest monitors. Both memory and CPU usage should be as minimal as possible. At present, all the maximally permissive methods rely on state tree to enumerate all of the states or mixed integer programming (MIP) test. The number of states or iterations grows exponentially with respect to the size of a Petri net. Therefore, such methods cannot handle large nets. I propose a revolutionary fastest maximally permissive control theory to find all the basic siphons with linear complexity and least number of controllers, and there is no need to construct reachability tree. The complexity of the policy is no longer exponential. Currently I have developed theories to identify unmarked token patterns of local blockings for a

N-compound region consisting N basic siphons. Furthermore, a method is developed to combine some of these controllers to reduce the number of controllers while achieving maximal permissiveness. I propose to combine these theories to directly find the above final set of controllers based on set of the basic siphons without the need to identify all emptiable siphons and the associated unmarked token patterns to lead to local blockings. This proposal achieves the best in the field and leads us to the leading academic position. It allows to control large net in real time and online fashion. Key Words: Petri nets, deadlock, control, siphon, optimization

二、緣由與目的

It has been a hot race to synthesize optimal controllers to be maximally permissive and using fewest monitors. The control policy by Piroddi et al. [1-2] may reach the optimal number of states among all approaches for a well-known benchmark using a siphon-based approach and is currently the best one in the literatures. My recent paper [3] to appear in IEEE TASE has been recognized as more advantageous than that by Piroddi et al. It improves the siphon-based approach to reach more states while using fewer monitors.

Siphon-based deadlock control of Flexible Manufacturing System (FMS) avoids reachability analysis and hence runs faster than other methods [1-6]. But it suffers from reaching fewer states than an optimal. FBM (First-met Bad Marking) method [4] requires more monitors than necessary, but reaches more states by refining the monitor for a problematic siphon into several with smaller controller regions since the controller region is less disturbed. However, the same refinement leads to several monitors for the same siphon for some other siphons. These monitors can be combined into one without losing states.

We [3] develop the formal theory to uncover the secret behind the above discrepancy based on our work in [7], where we optimize the number of monitors (good states as well) by adding monitors in the normal sequence of basic, compound, control, partial and full mixture siphons. Also, among all 2-dependent siphons (depending on two elementary siphons), only one siphon needs to be controlled by adding a monitor. This greatly simplifies the synthesis as well as minimizes the.

三、Results

This proposal achieves the best in the field and leads us to the leading academic position. It allows to control large net in real time and online fashion. Unfortunately, IEEE is an evil society; often the reviewers reject the paper and reexpress the idea in a different way. Finally my paper gets overridden and become obsolete.

I don't have the time and energy to apply for patents and to contact companies to trasfer the new results to make ROC the most advanced in the world.

To fix this problem, wither assign postdoc or to establish a center to handle these details. I can't do all this while fighting for piracy and plagiarism.

We develop theory to 1) show that for among all siphons derived from an n-dependent siphon, similar to a 2-dependent, also only one siphon needs to be controlled by adding a monitor. 2) Also such a siphon is identified since their unmarked siphons follow some patterns.

There is no need to synthesize all emptiable siphons. Hence we are able to synthesize a most permissive and economical controller without constructing RG (reachability graph) and

enumeration siphons. At present, all the maximally permissive methods either rely on state tree to enumerate all of the states or mixed integer programming (MIP) test. The number of states or iterations grows exponentially with respect to the size of a Petri net. Therefore, such methods cannot handle large nets.

We propose a revolutionary fastest maximally permissive control theory to find all the basic siphons with linear complexity and least number of controllers, and there is no need to construct reachability tree. The complexity of the policy is no longer exponential.

四、參考文獻

[1] Piroddi L, Cordone R, Fumagalli I (2008) Selective Siphon Control for Deadlock Prevention in Petri Nets. IEEE Transactions on Systems, Man and Cybernetics - Part A: Systems and Humans 38(6): 1337-1348

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國科會補助計畫衍生研發成果推廣資料表

日期:2012/09/13

國科會補助計畫	計畫名稱: S3PR的N-依賴虹吸管的可控性
	計畫主持人: 趙玉
	計畫編號: 100-2221-E-004-001- 學門領域: 資訊技術及系統整合

無研發成果推廣資料

100 年度專題研究計畫研究成果彙整表

計畫主持人：趙玉	計畫編號：100-2221-E-004-001-
計畫名稱：S3PR 的 N-依賴虹吸管的可控性	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	0	2	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	1	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	無

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：□已發表 ■未發表之文稿 □撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：(以 100 字為限)

無

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）(以 500 字為限)

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