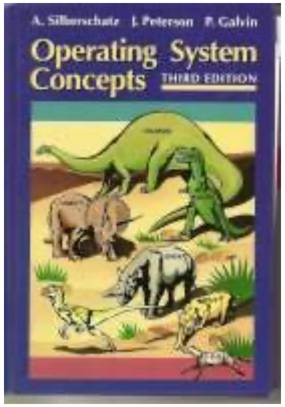
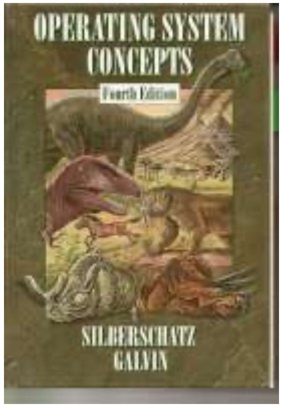
作業系統基本觀念複習 Process & Thread

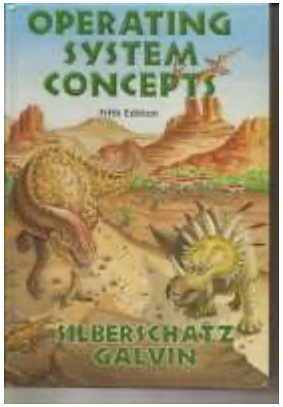
Yiling Lai

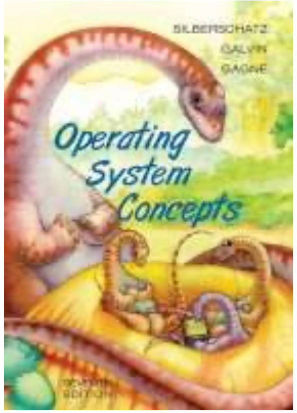
2011/8/24

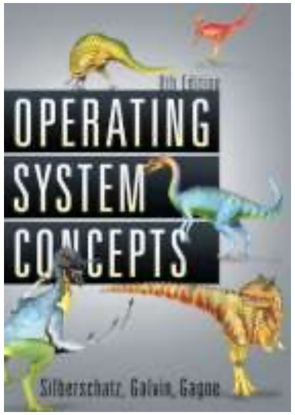
- 恐龍書
  Operating System Concepts
  Silberschatz, Galvin, Gagne


A. Silberschatz J. Peterson P. Galvin
Operating System Concepts
THIRD EDITION









什麼是Process?

- A program in execution. 執行中的程式

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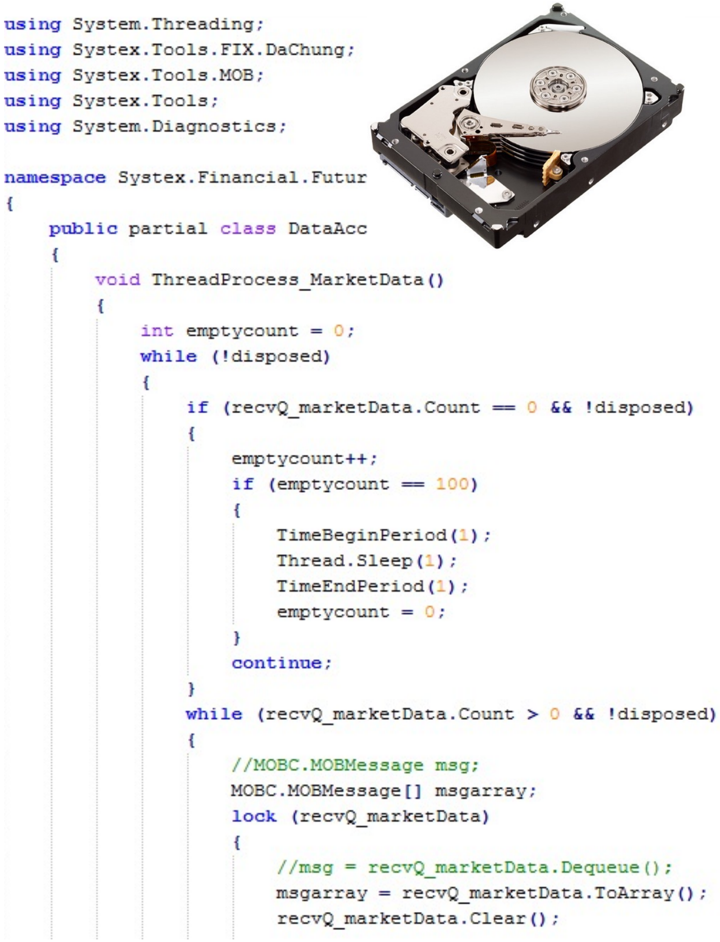

```
using System.Threading;
using Systex.Tools.FIX.DaChung;
using Systex.Tools.MOB;
using Systex.Tools;
using System.Diagnostics;

namespace Systex.Financial.Futur
{
    public partial class DataAcc
    {
        void ThreadProcess_MarketData()
        {
            int emptycount = 0;
            while (!disposed)
            {
                if (recvQ_marketData.Count == 0 && !disposed)
                {
                    emptycount++;
                    if (emptycount == 100)
                    {
                        TimeBeginPeriod(1);
                        Thread.Sleep(1);
                        TimeEndPeriod(1);
                        emptycount = 0;
                    }
                    continue;
                }
                while (recvQ_marketData.Count > 0 && !disposed)
                {
                    //MOBC.MOBMessage msg;
                    MOBC.MOBMessage[] msgarray;
                    lock (recvQ_marketData)
                    {
                        //msg = recvQ_marketData.Dequeue();
                        msgarray = recvQ_marketData.ToArray();
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```

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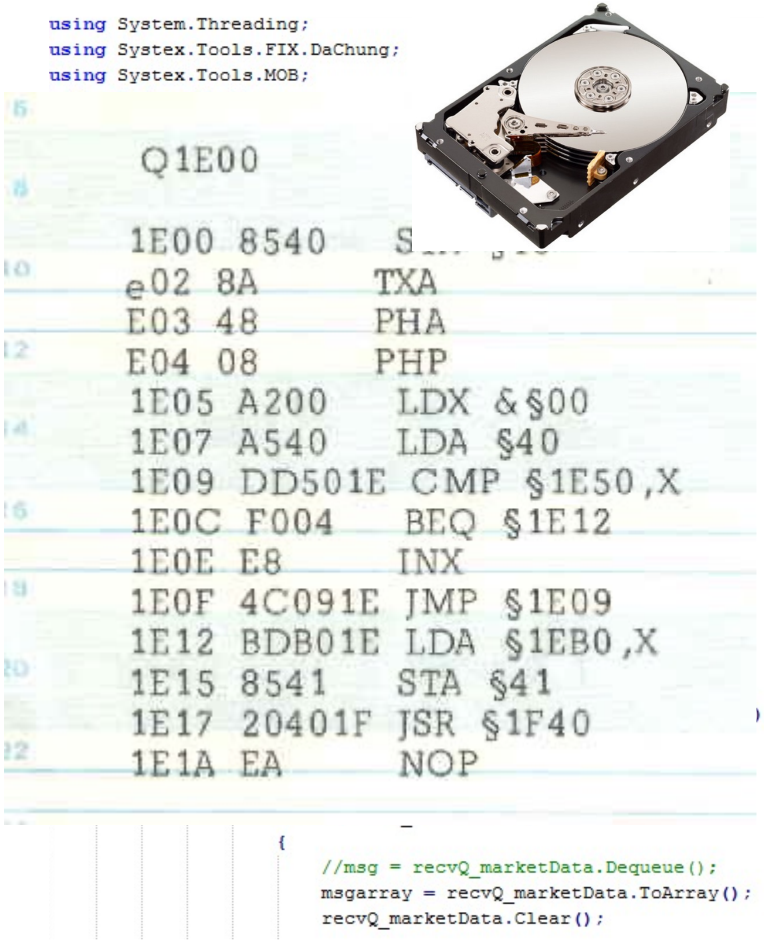

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```
Q1E00

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E03 48     PHA
E04 08     PHP
1E05 A200   LDX &$00
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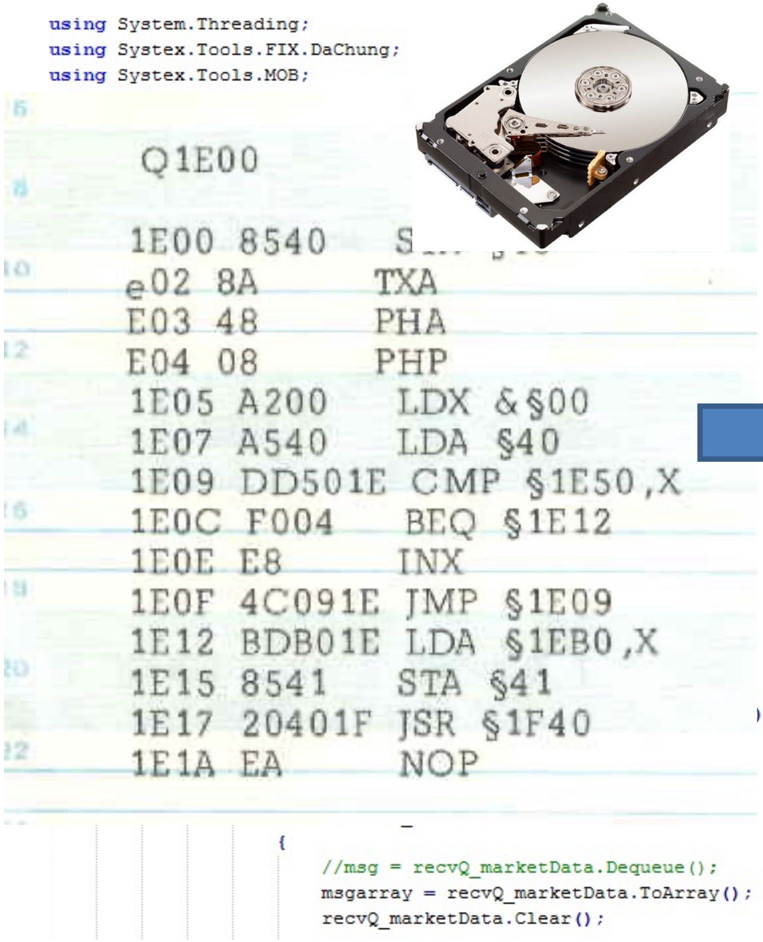

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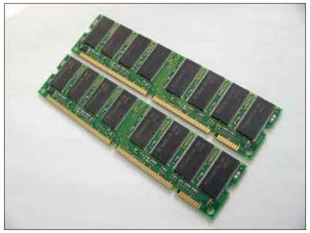

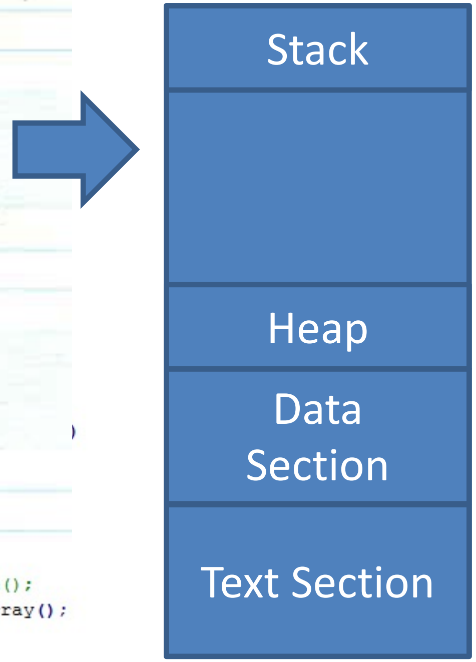

Program counter

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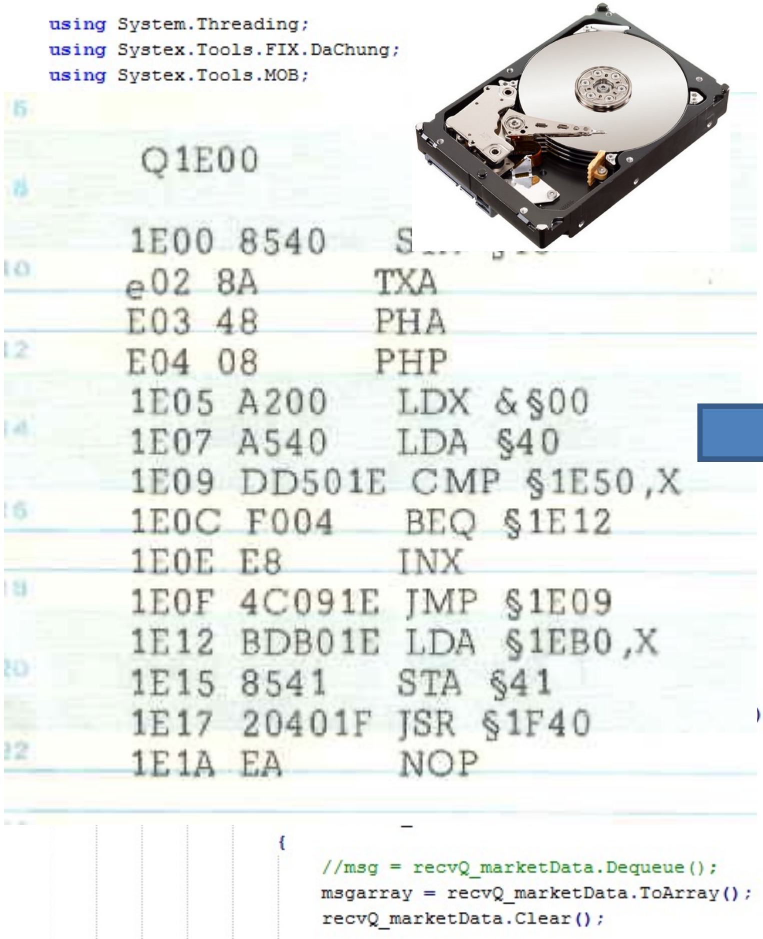

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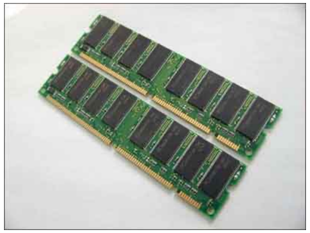
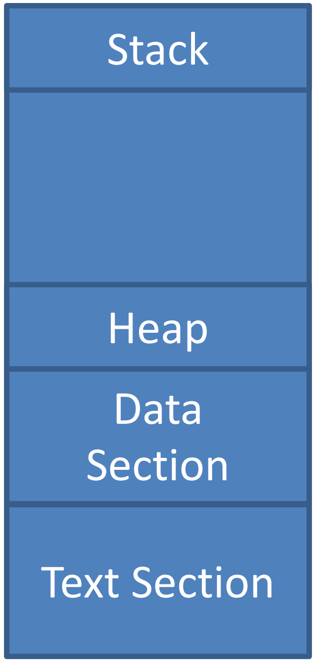


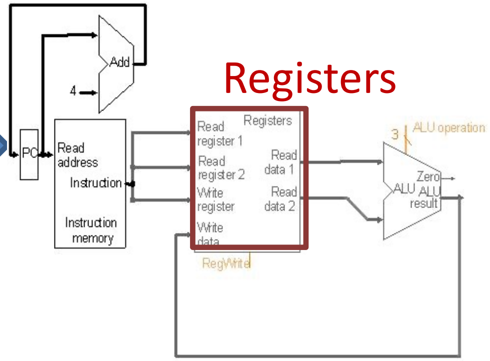


Stack

Heap

Data Section

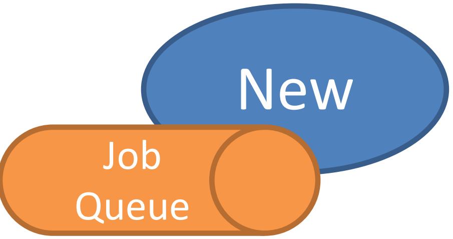
Text Section



Registers

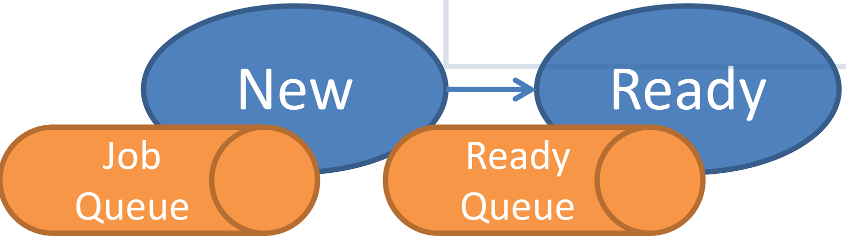
Program counter

Process的一生 (STD)



Process的一生 (STD)

Load到memory裡，準備搶CPU控制權



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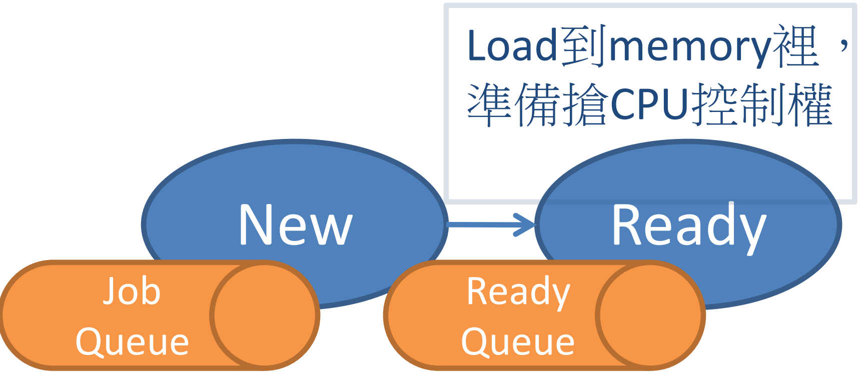

Load到memory裡，準備搶CPU控制權

PCB

Process ID
Process State
PC
CPU Registers
….

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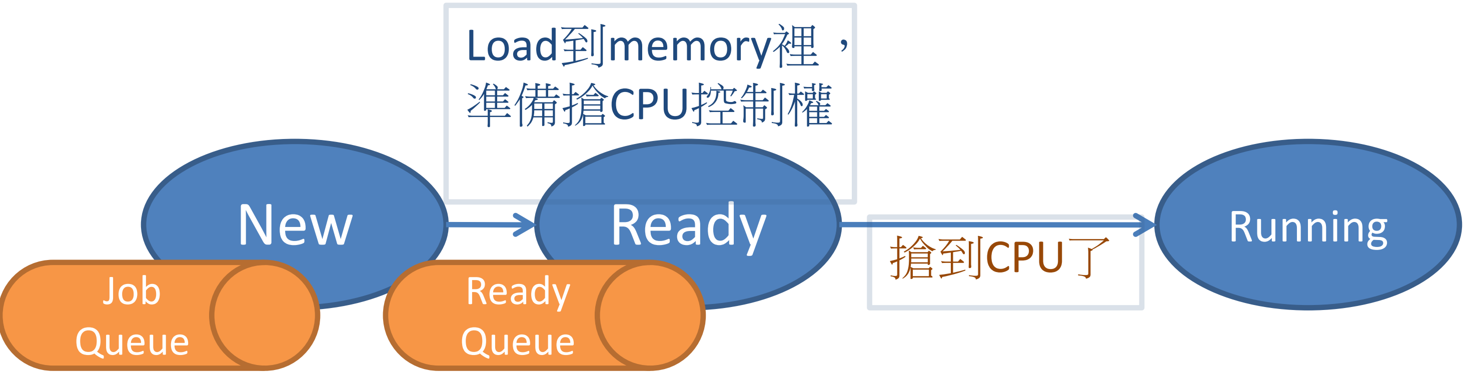
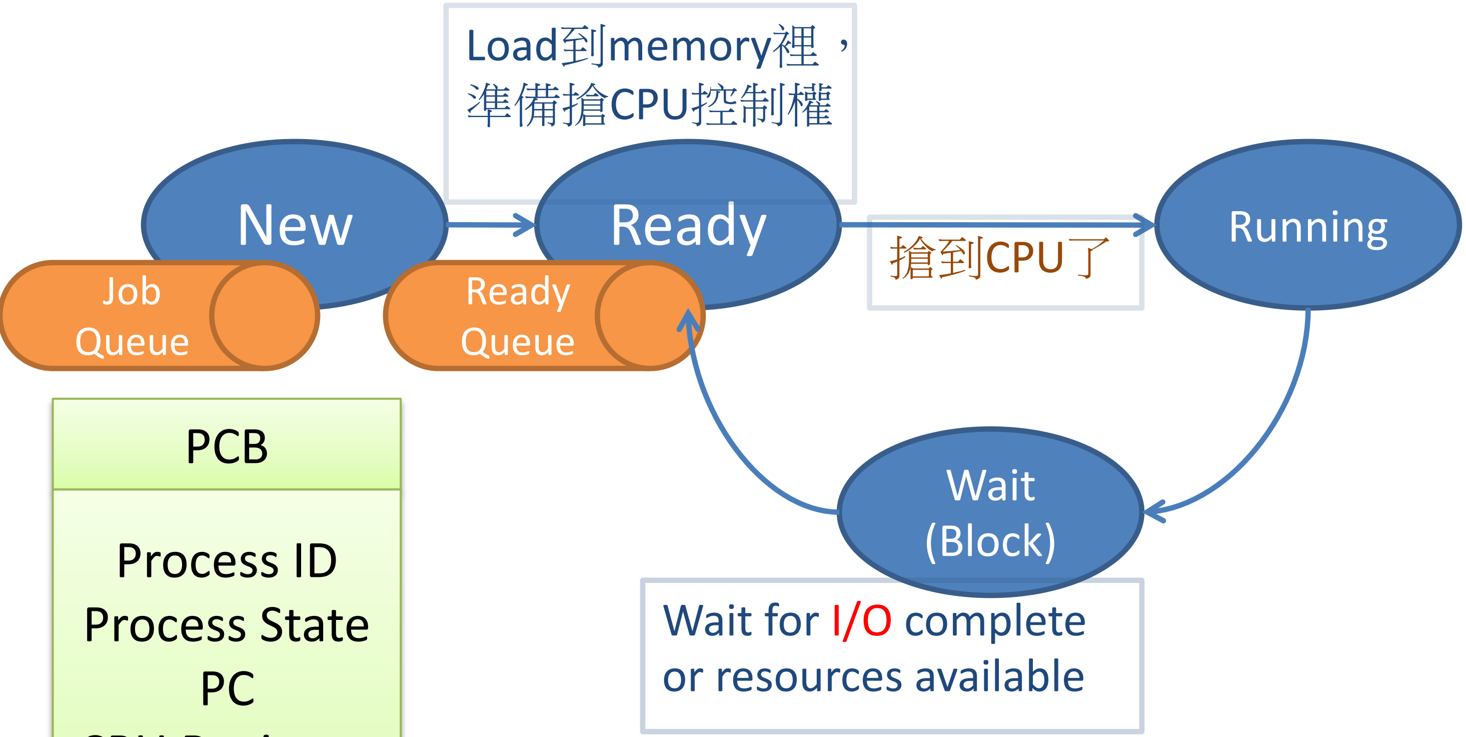

Load到memory裡，準備搶CPU控制權

搶到CPU了

PCB
Process ID Process State PC CPU Registers ….

Process的一生 (STD)



Load到memory裡，準備搶CPU控制權

搶到CPU了

Wait for I/O complete or resources available

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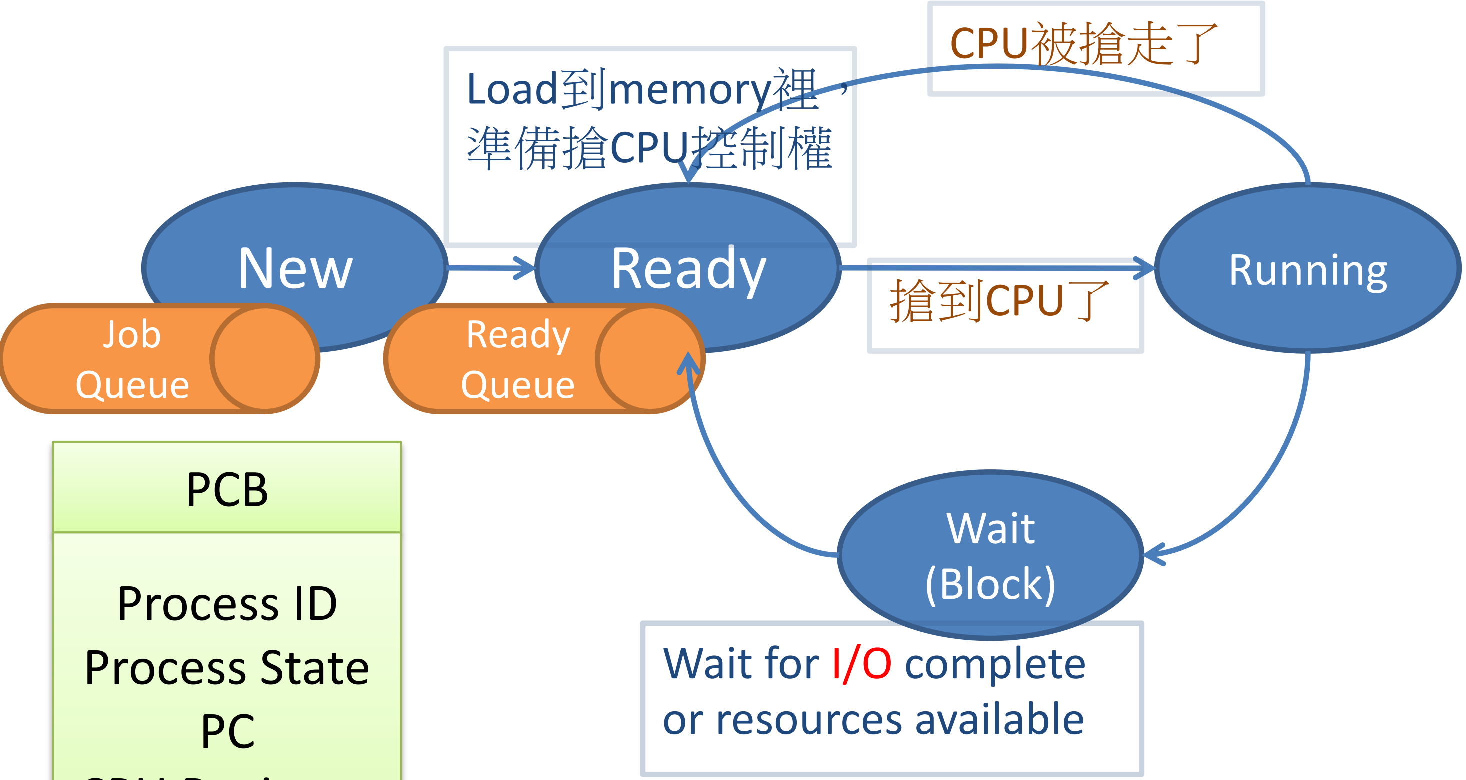

New

Ready

Running

Wait
(Block)

Job
Queue

Ready
Queue

Load到memory裡，
準備搶CPU控制權

CPU被搶走了

搶到CPU了

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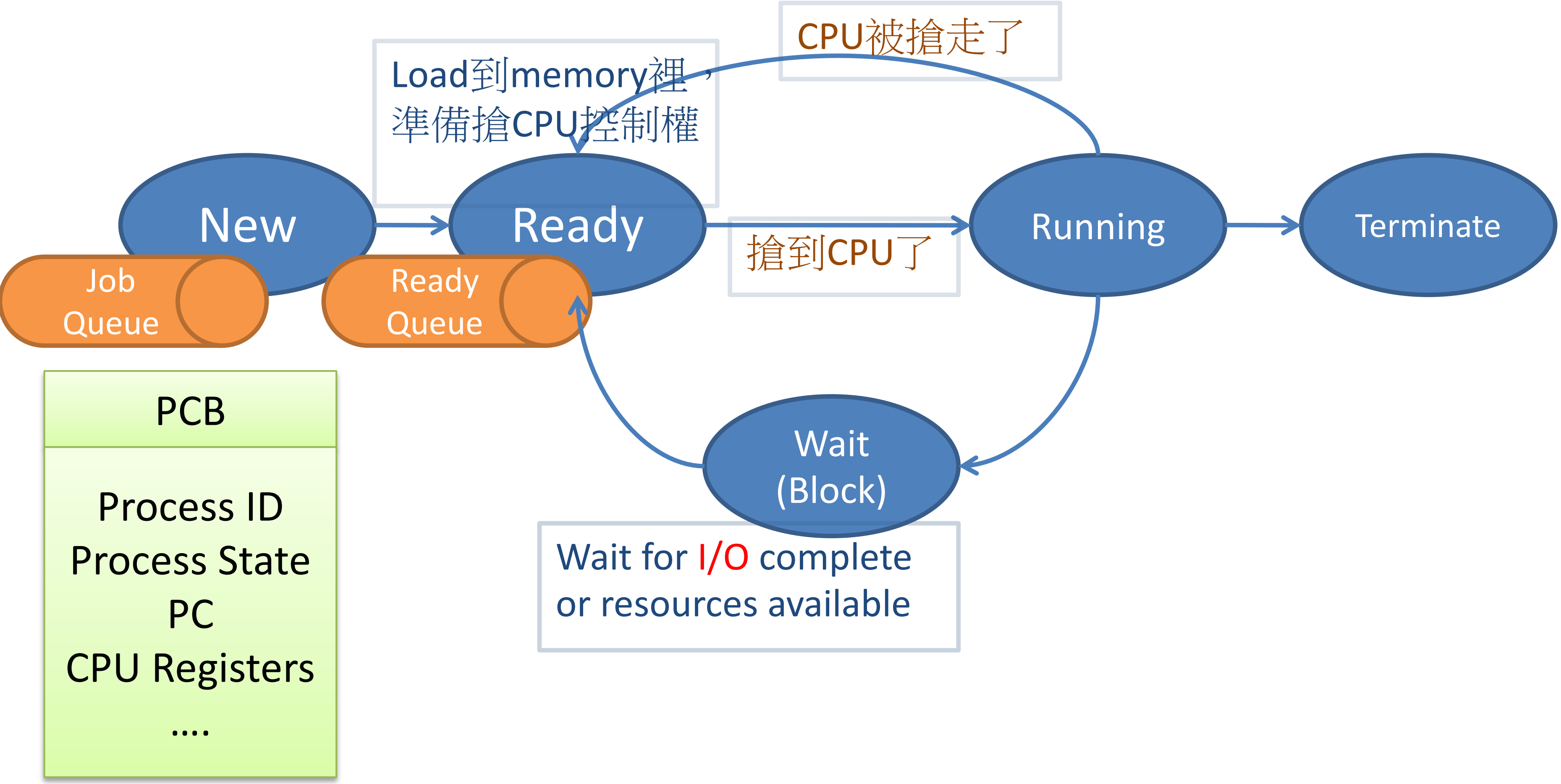

Load到memory裡，準備搶CPU控制權

CPU被搶走了

New

Ready

Running

Terminate

搶到CPU了

Job Queue

Ready Queue

Wait (Block)

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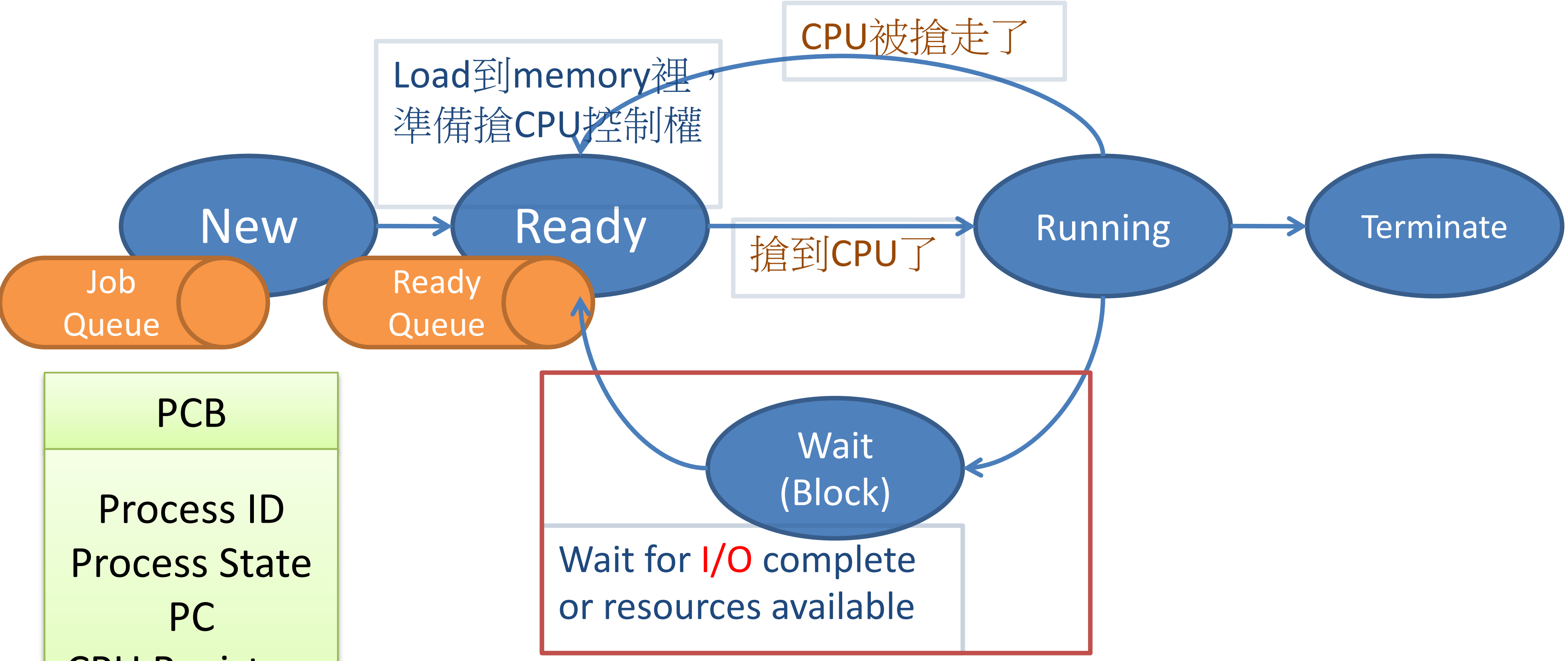

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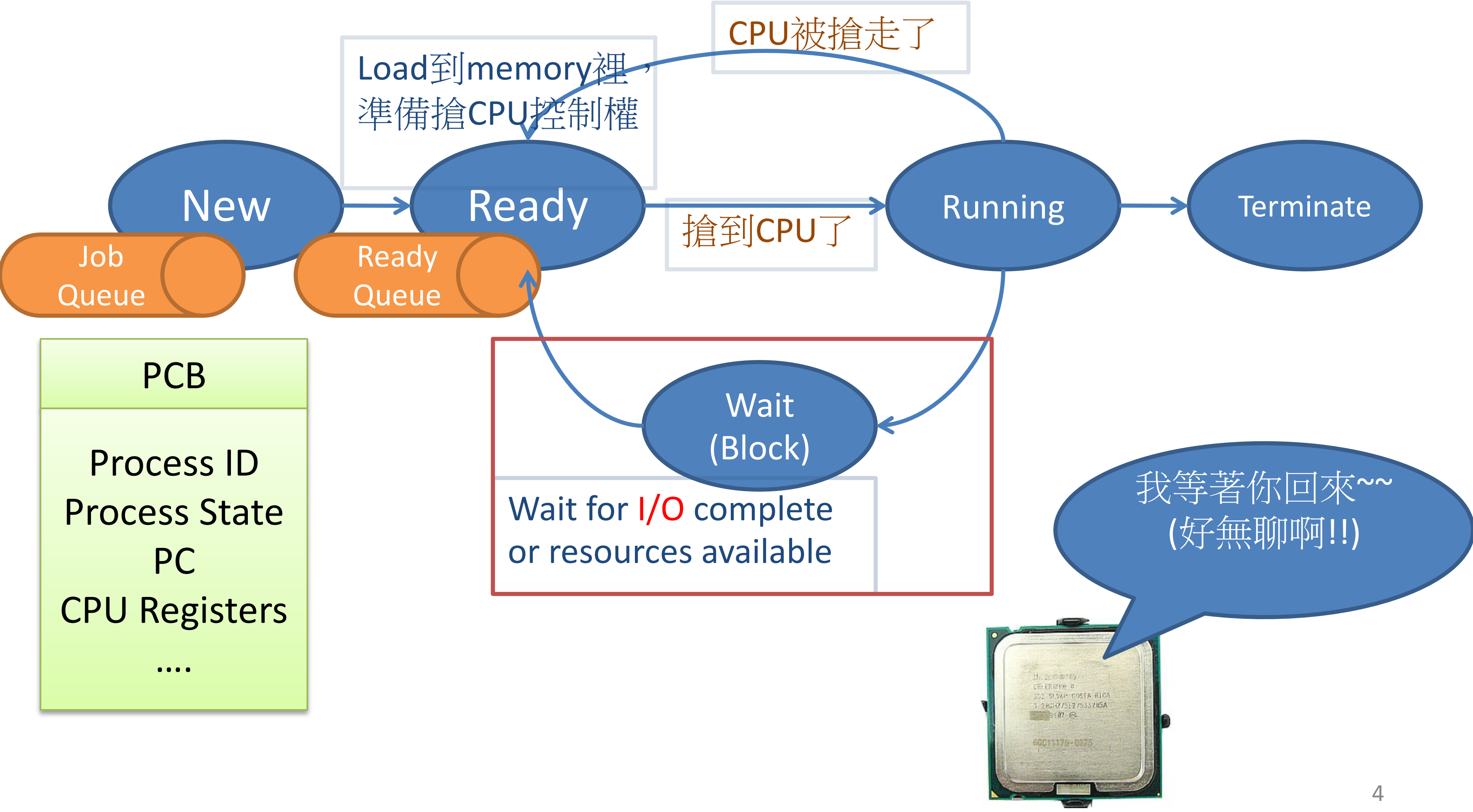

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多找幾個行程來填
補我的空虛與寂寞!!
(Concurrent Processing)

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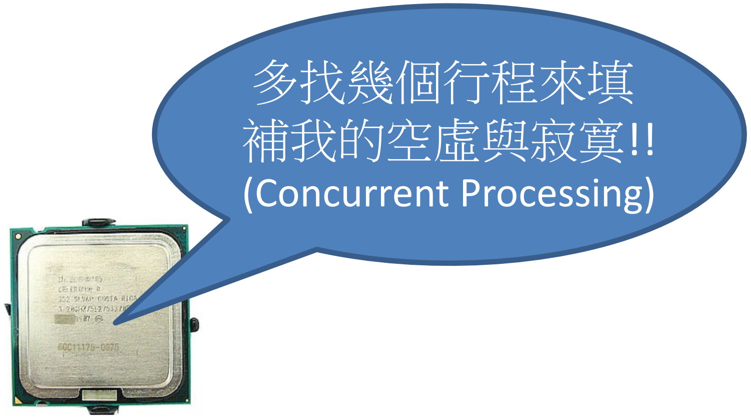
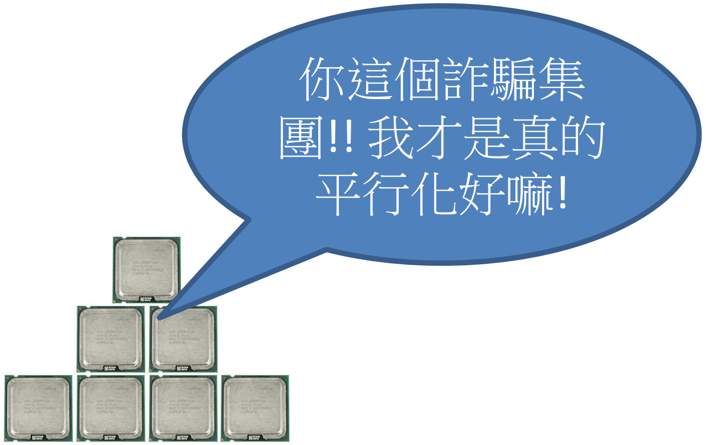
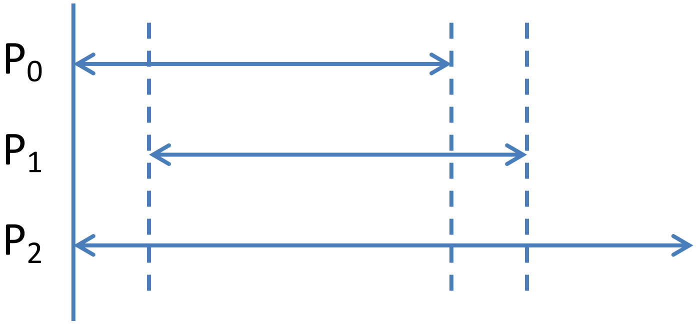
你這個詐騙集
團!! 我才是真的
平行化好嘛!





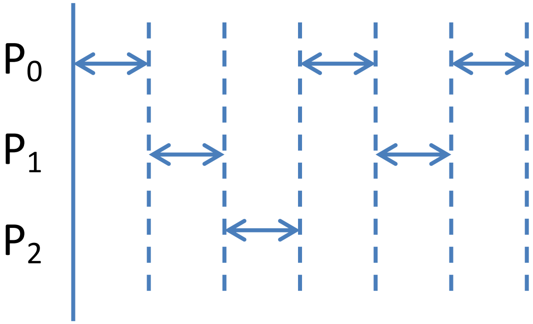
Parallel Processing



多找幾個行程來填補我的空虛與寂寞!!
(Concurrent Processing)

你這個詐騙集團!! 我才是真的平行化好嘛!

Concurrnt Processing



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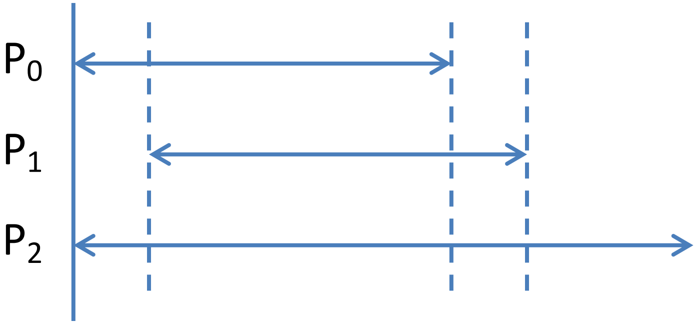

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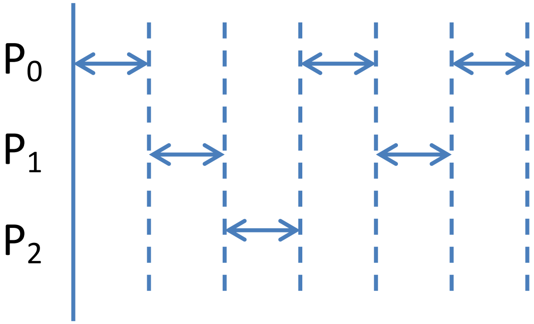

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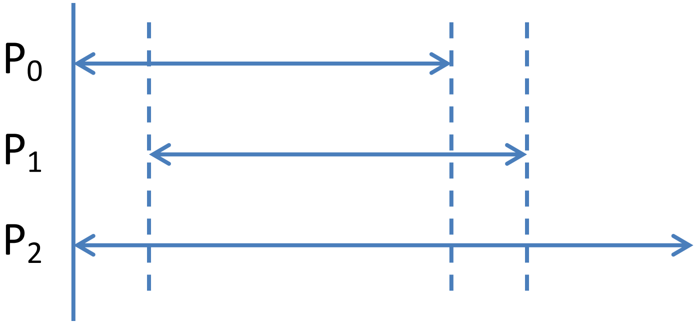

大家輪流使用CPU，但是怎麼輪？？

我就知道沒有我果然不行，交給我吧!!

1. CPU的使用率(Utilization)要最大
2. 工作產能(Throughput)要高
3. Process等待的時間要短
4. 完成時間(Turnaround time)要短
5. 資源利用率也要大
6. 要公平
7. …

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- FIFO: First come first out
- SJF: Shortest Job First
- SRJF: Shortest Remaining Time Job First
- Priority Scheduling
- RR: Round Robin
- …..

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Scheduling Algorithm

FIFO: 誰先來誰先做

SJF: 你要3個小時？我只要3分鐘，先給我用一下吧~

(SJF: shortest time job first)

Process	CPU Time
P_0	14
P_1	5
P_2	2

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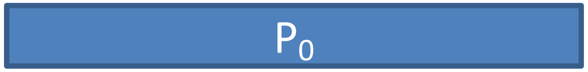

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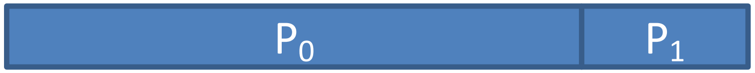

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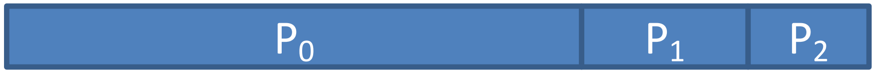

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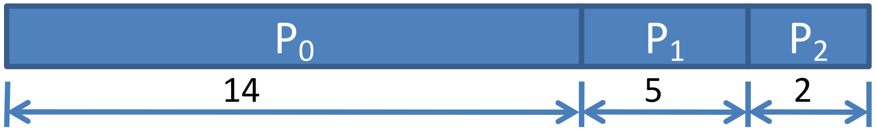

平均等待時間 = (0+ 14+19)/3 = 11

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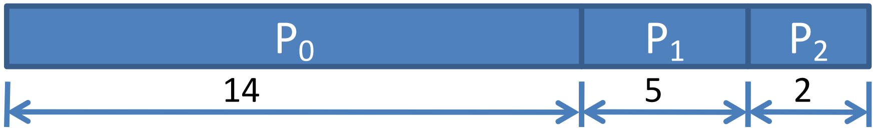

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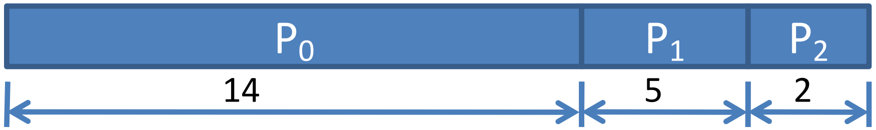

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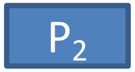

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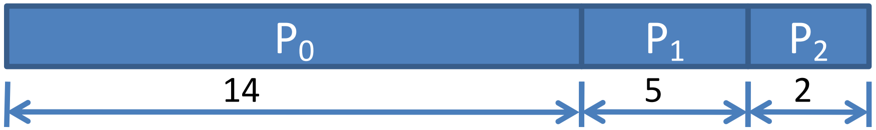
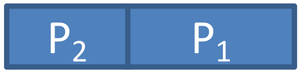


平均等待時間 = (0+ 14+19)/3 = 11

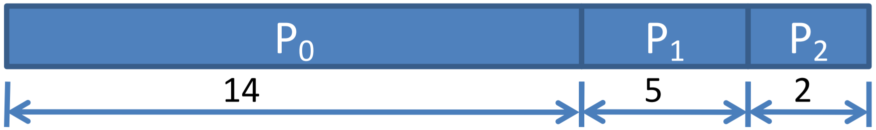
SJF：



FIFO: 誰先來誰先做
SJF: 你要3個小時？我只要3分鐘，先給我用一下吧~
(SJF: shortest time job first)

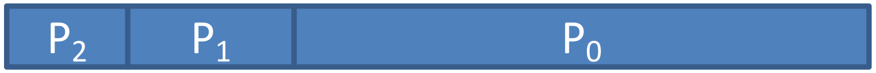
Process	CPU Time
P_0	14
P_1	5
P_2	2

FIFO：



平均等待時間 = (0+ 14+19)/3 = 11

SJF：



1. CPU的使用率要最大
2. 工作產能要高
3. Process等待的時間要短
4. 完成時間要短
5. 資源利用率也要大
6. 要公平

FIFO: 誰先來誰先做
SJF: 你要3個小時？我只要3分鐘，先給我用一下吧~
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Process	CPU Time
P_0	14
P_1	5
P_2	2

1. CPU的使用率要最大
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3. Process等待的時間要短
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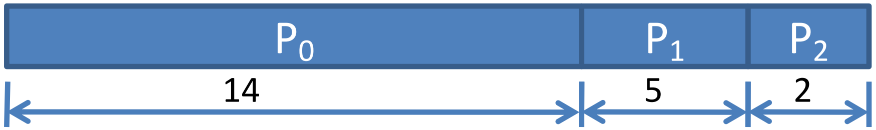
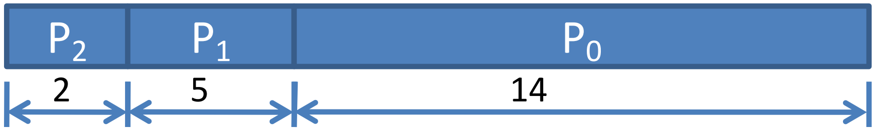
FIFO：



平均等待時間 = (0+ 14+19)/3 = 11

SJF：



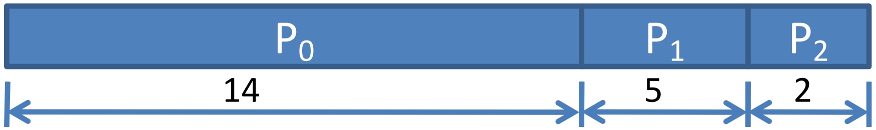
平均等待時間 = (0+2+7)/3 = 3

FIFO: 誰先來誰先做
SJF: 你要3個小時？我只要3分鐘，先給我用一下吧~
(SJF: shortest time job first)

Process	CPU Time
P_0	14
P_1	5
P_2	2

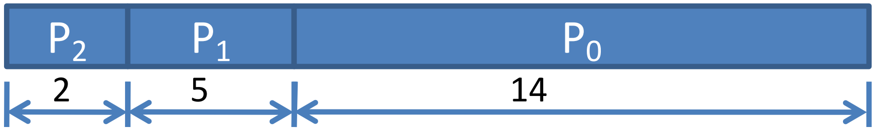
1. CPU的使用率要最大
2. 工作產能要高
3. Process等待的時間要短
4. 完成時間要短
5. 資源利用率也要大
6. 要公平

FIFO：



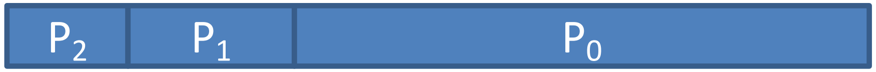
平均等待時間 = (0+ 14+19)/3 = 11

SJF：

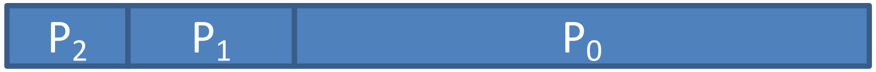


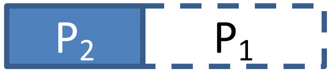
平均等待時間 = (0+2+7)/3 = 3

Process	CPU Time
P_0	14
P_1	5
P_2	2

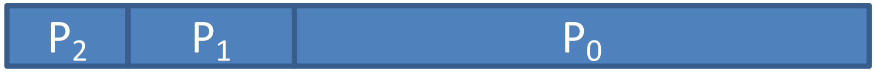


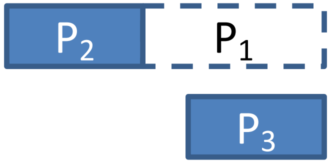
Process	CPU Time
P_0	14
P_1	5
P_2	2


P_2 P_1 P_0


P_2 P_1

Process	CPU Time
P_0	14
P_1	5
P_2	2





Process	CPU Time
P_0	14
P_1	5
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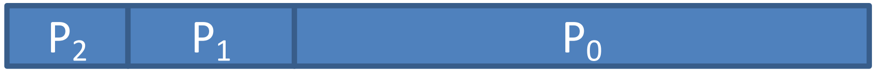
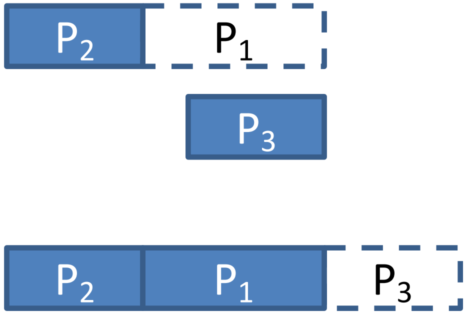
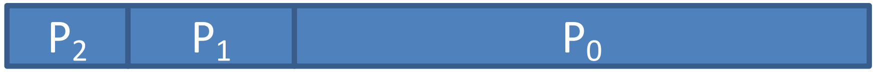
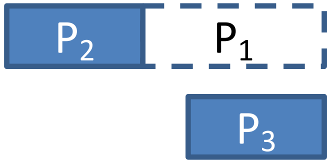
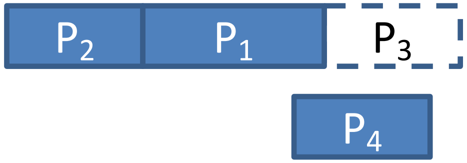




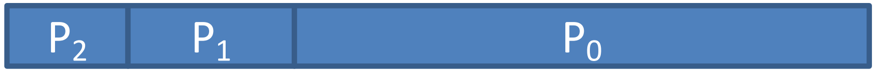
Process	CPU Time
P_0	14
P_1	5
P_2	2

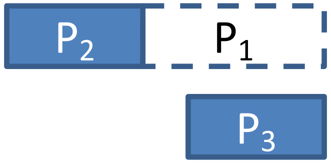


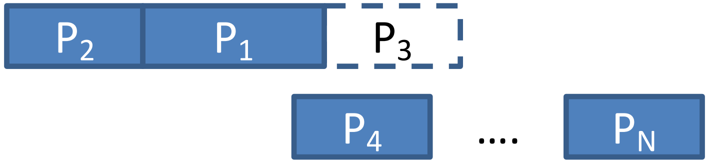




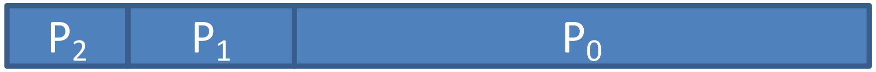
Process	CPU Time
P_0	14
P_1	5
P_2	2

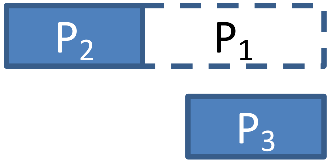




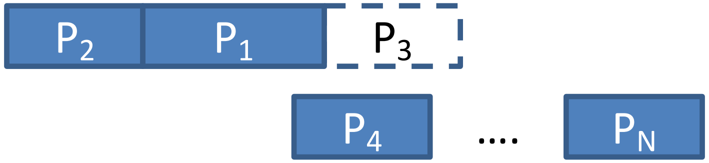


Process	CPU Time
P_0	14
P_1	5
P_2	2

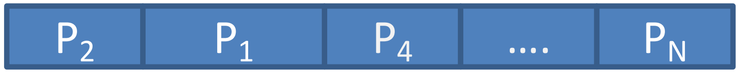

P_2 P_1 P_0


P_2 P_1

P_3


P_2 P_1 P_3

P_4 …. P_N


P_2 P_1 P_4 …. P_N

Process	CPU Time
P_0	14
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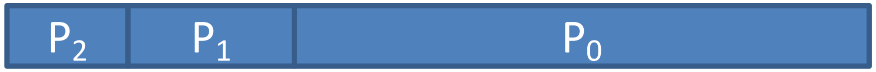
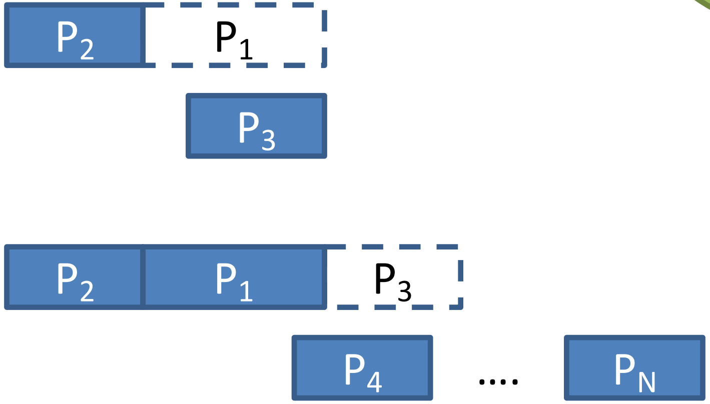
P_2	2

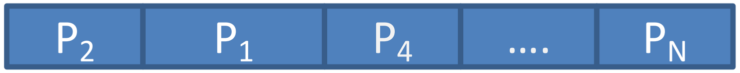

P_2 P_1 P_0


P_2 P_1

P_3

P_2 P_1 P_3

P_4 …. P_N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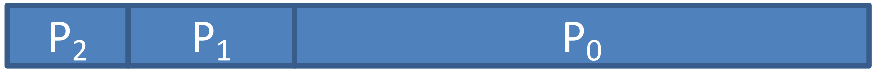
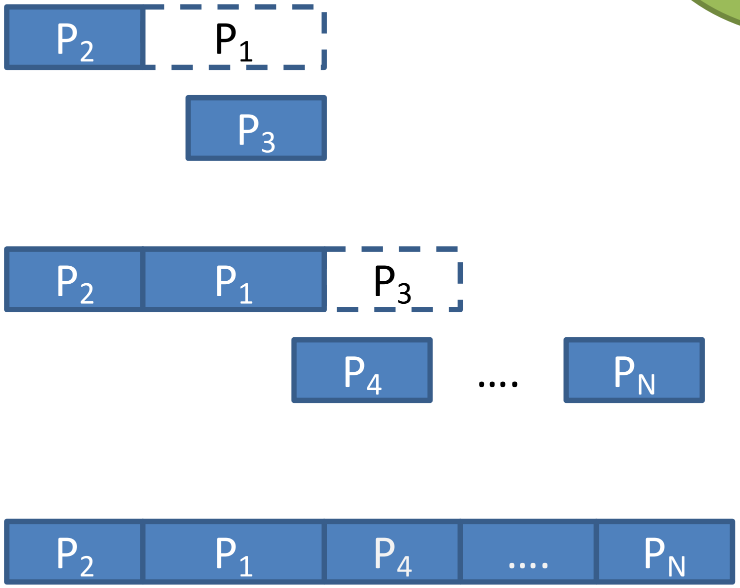


P_2 P_1 P_0



P_2 P_1

P_3

P_2 P_1 P_3

P_4 …. P_N

P_2 P_1 P_4 …. P_N

P_0

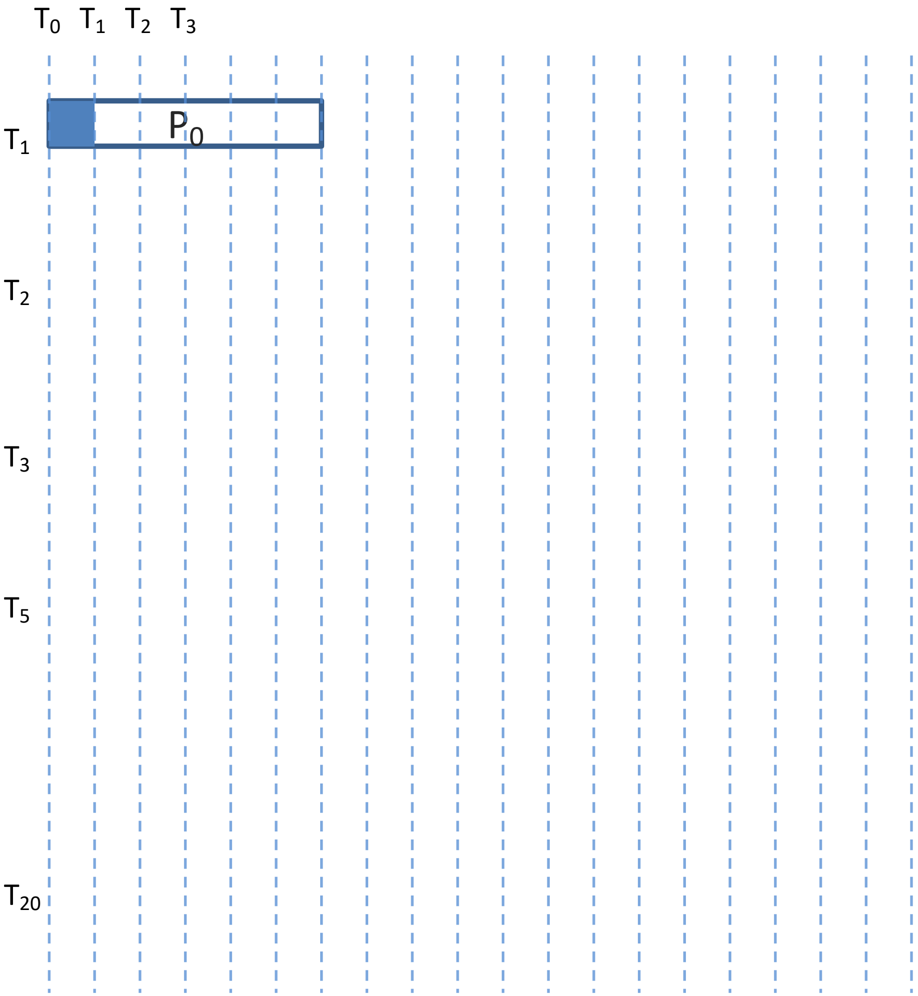
Starvation 飢餓：Process因為長期無法取得完工所需的全部資源，以致形成indefinite blocking之現象。

解法：Aging Tech等…

SRJF: Shortest Remaining Time Job First

- 可插隊的。

Process	Arrival Time	CPU Time
P_0	0	6
P_1	1	4
P_2	2	7
P_3	3	3



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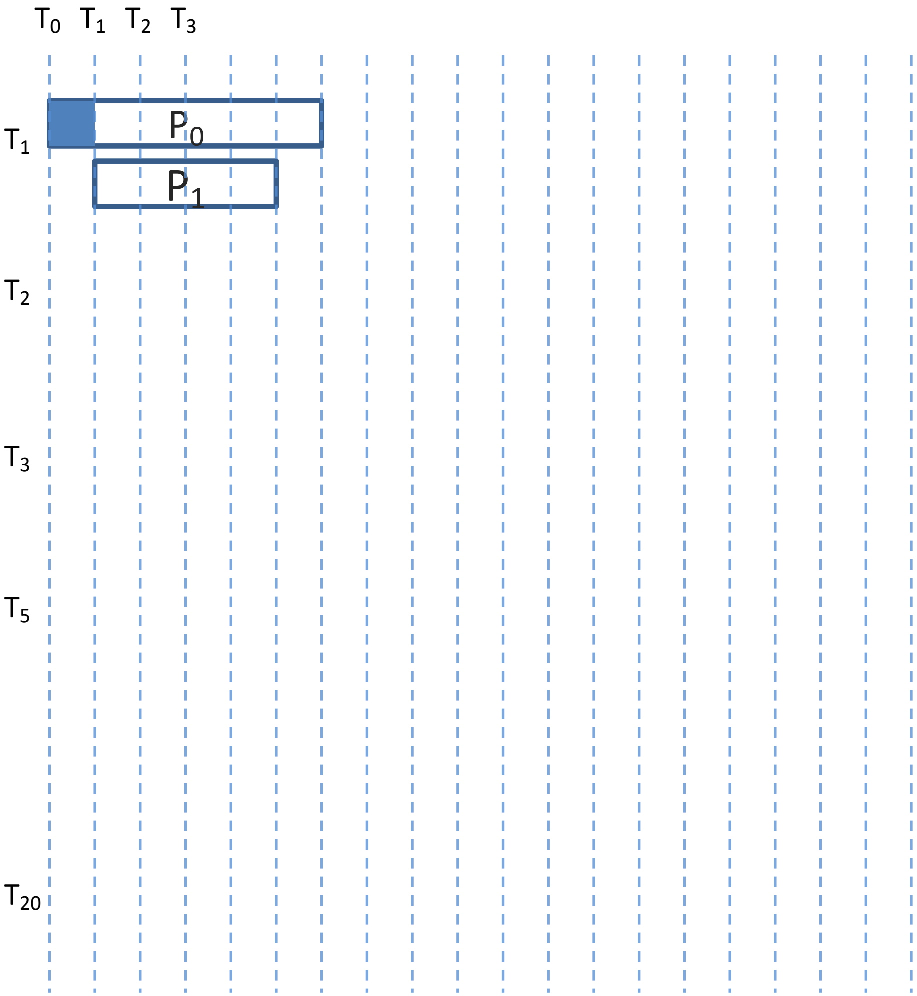

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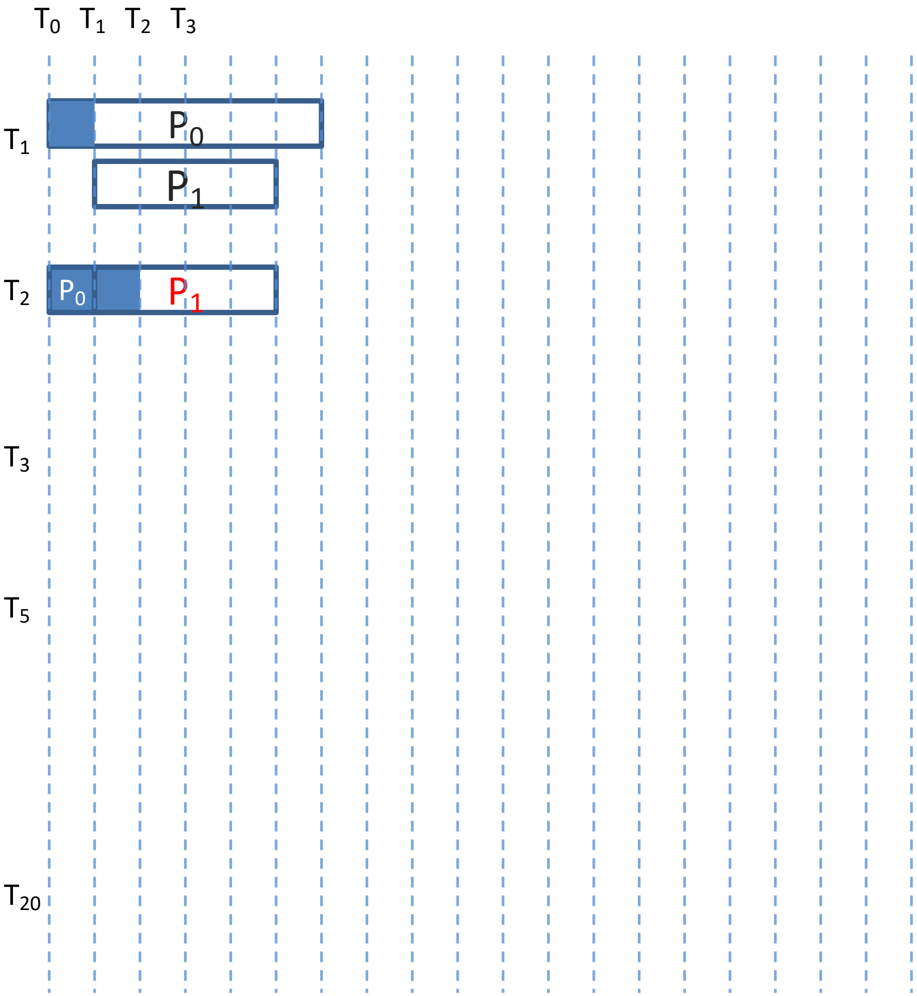

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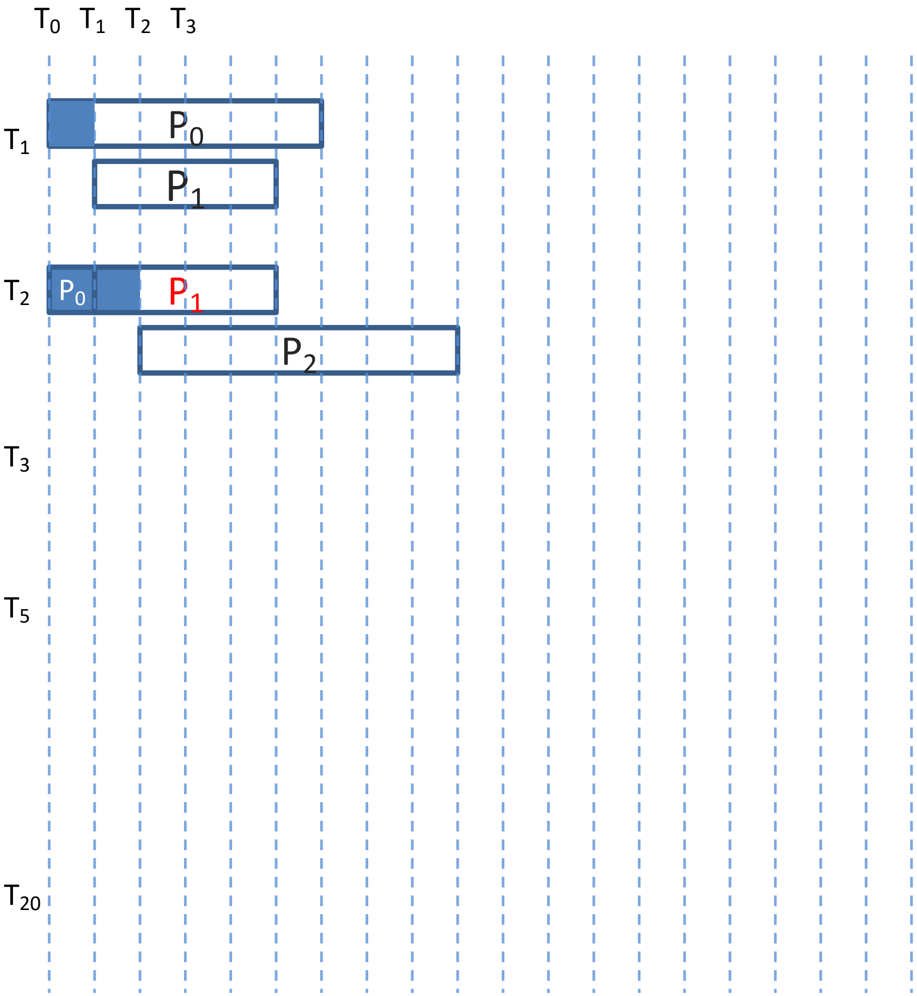

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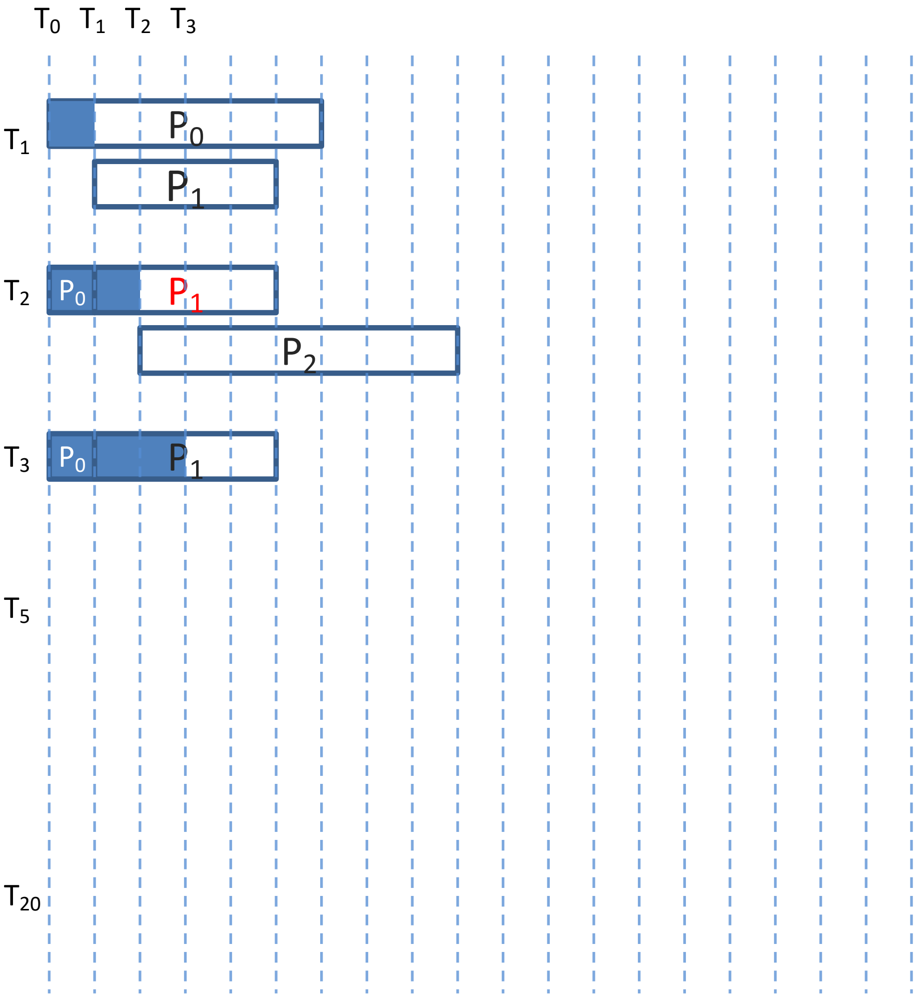

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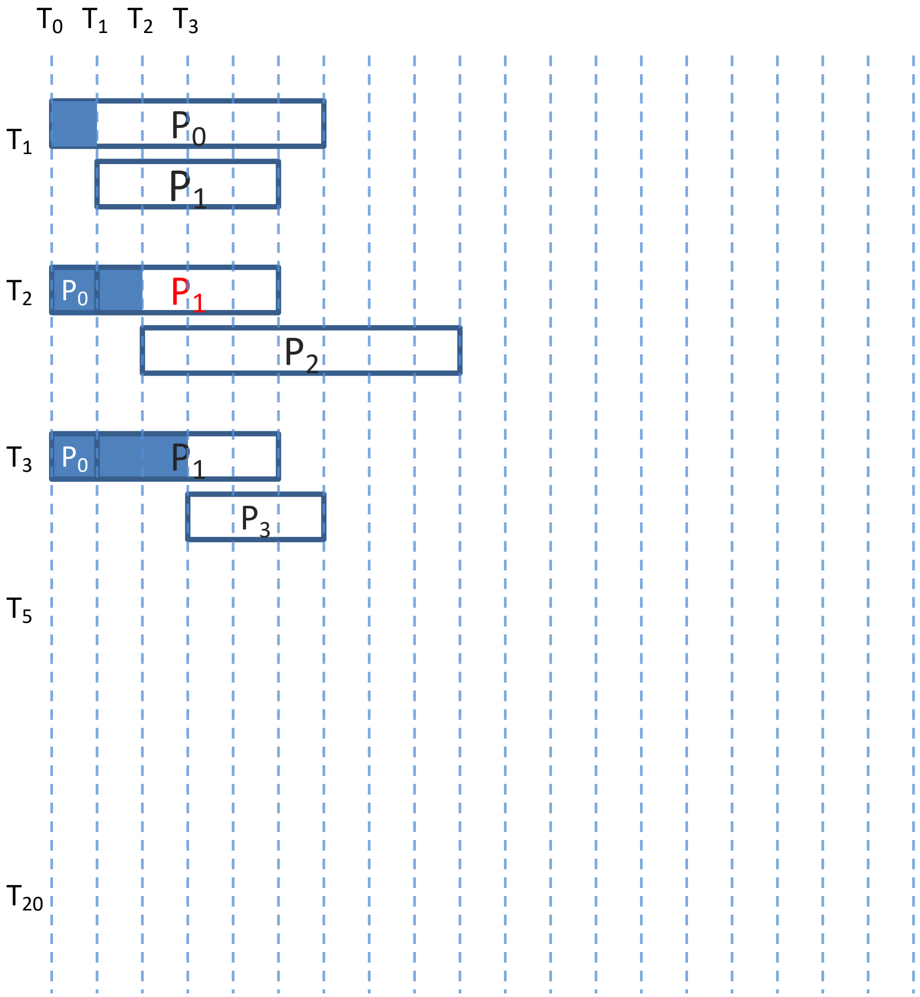

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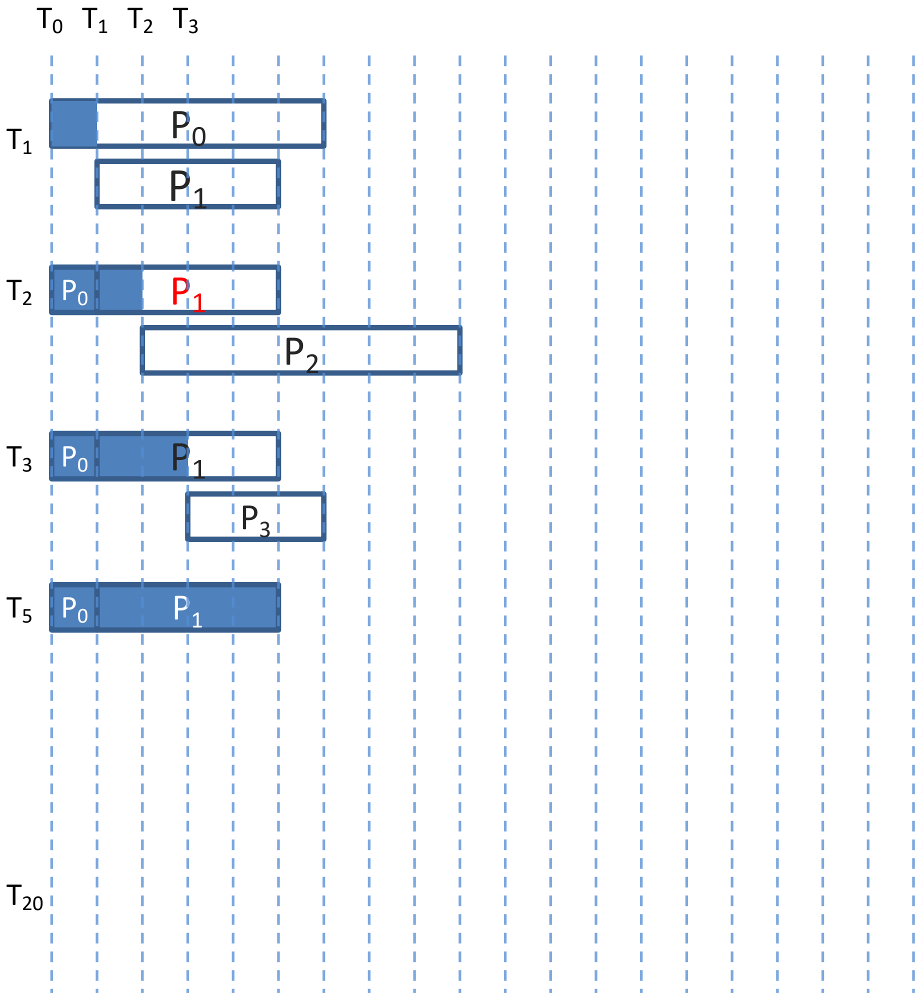

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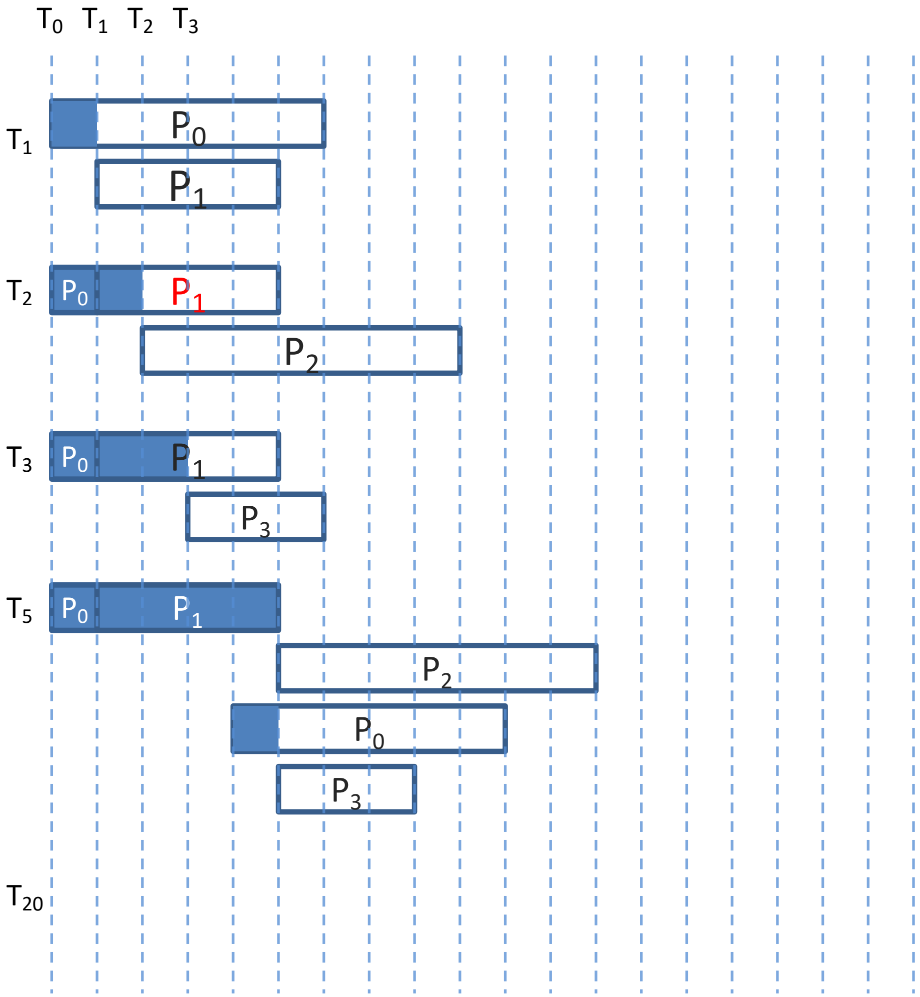

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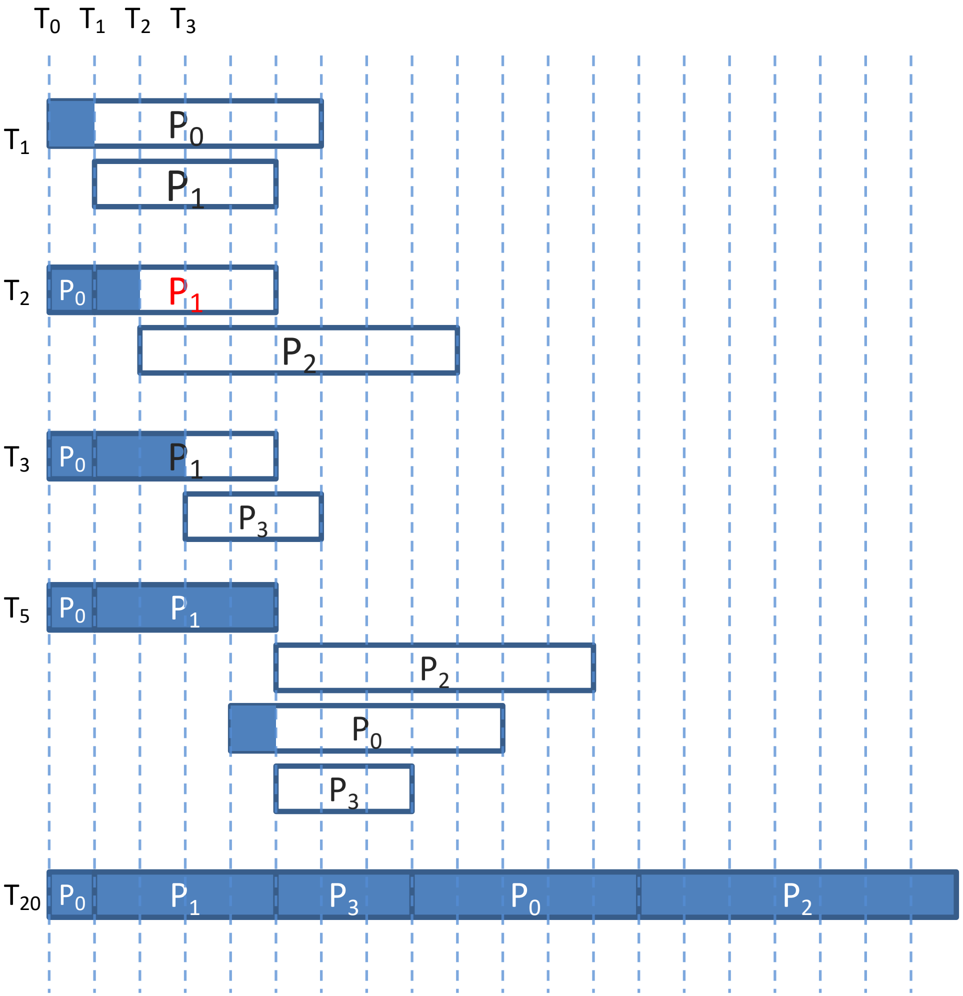
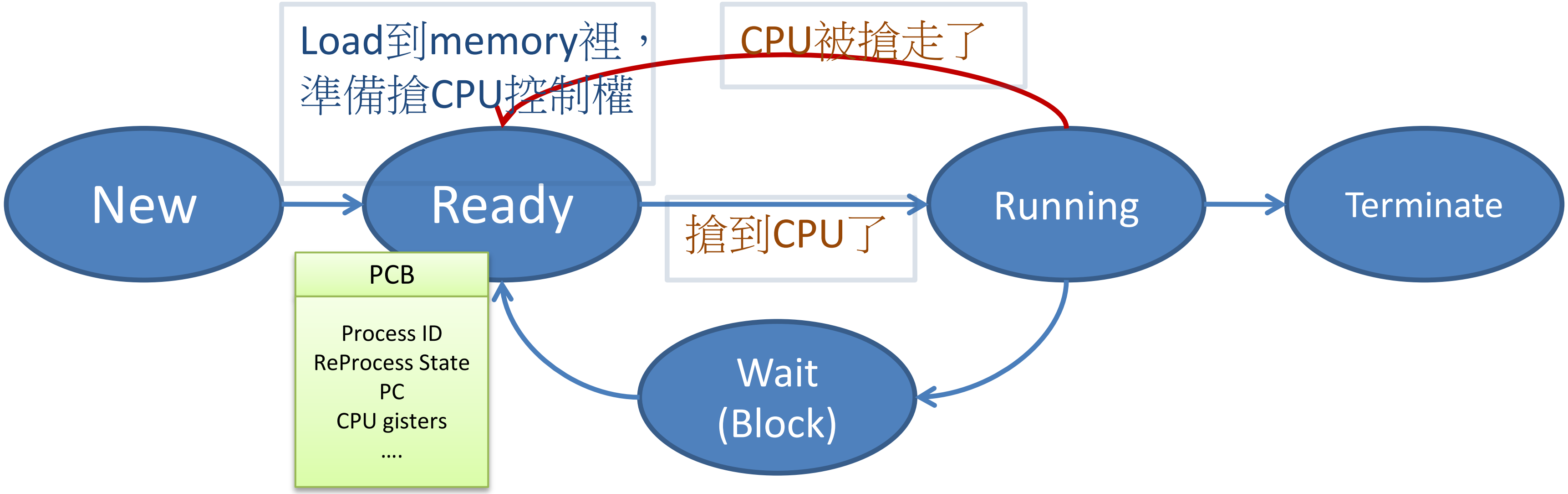




New

Ready

Running

Terminate

Wait
(Block)

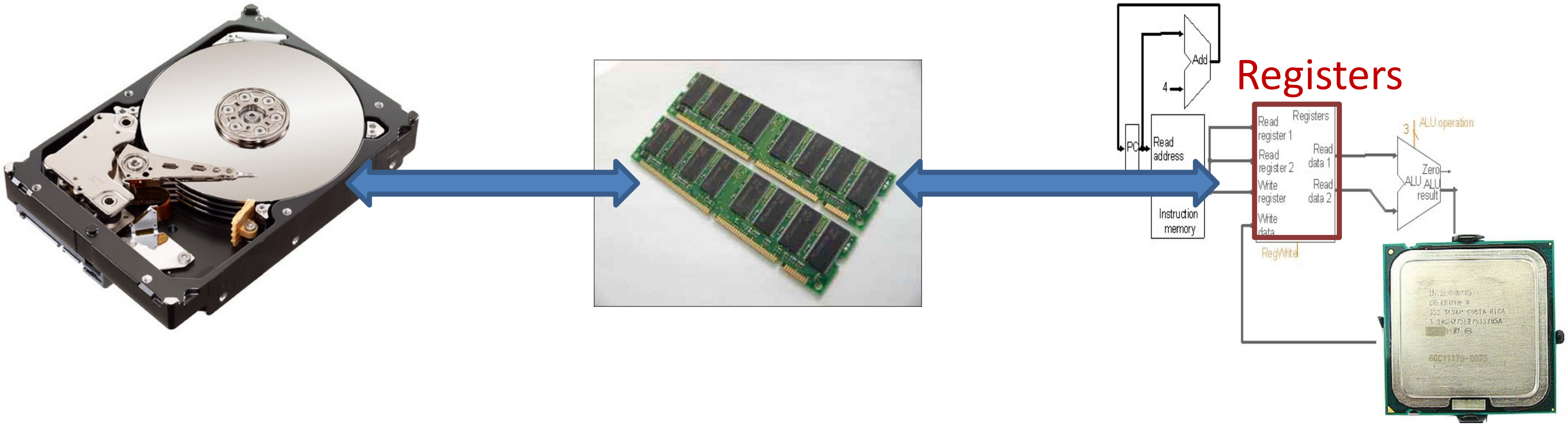
Load到memory裡，
準備搶CPU控制權

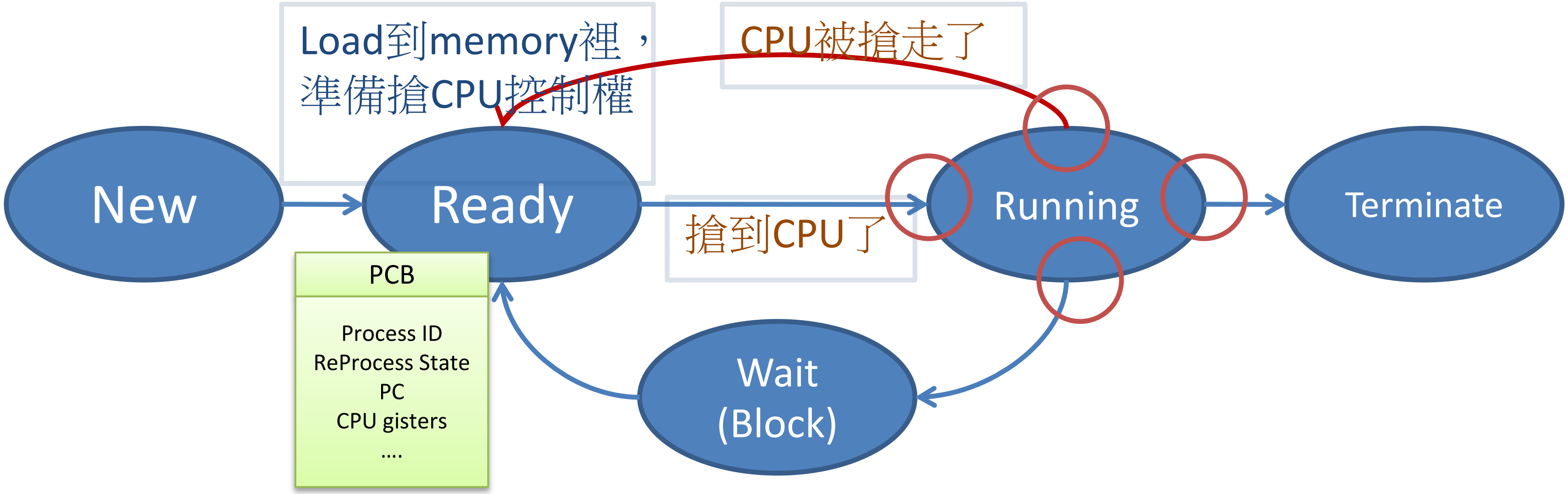
CPU被搶走了

搶到CPU了

PCB

Process ID
ReProcess State
PC
CPU gisters
....





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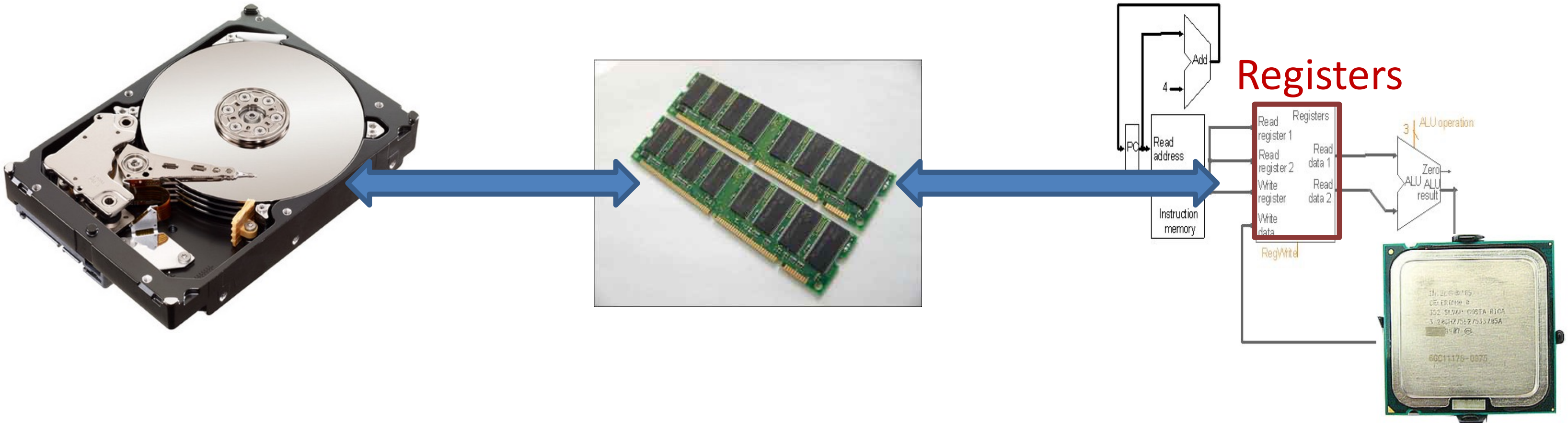
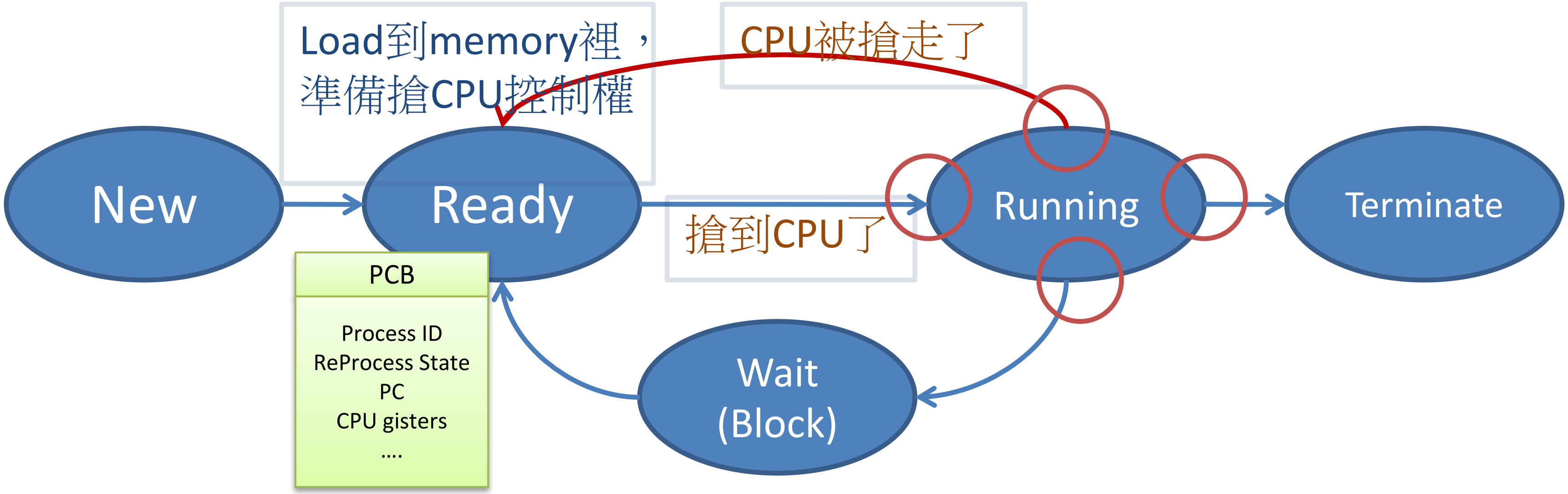




Load到memory裡，準備搶CPU控制權

CPU被搶走了

New

Ready

搶到CPU了

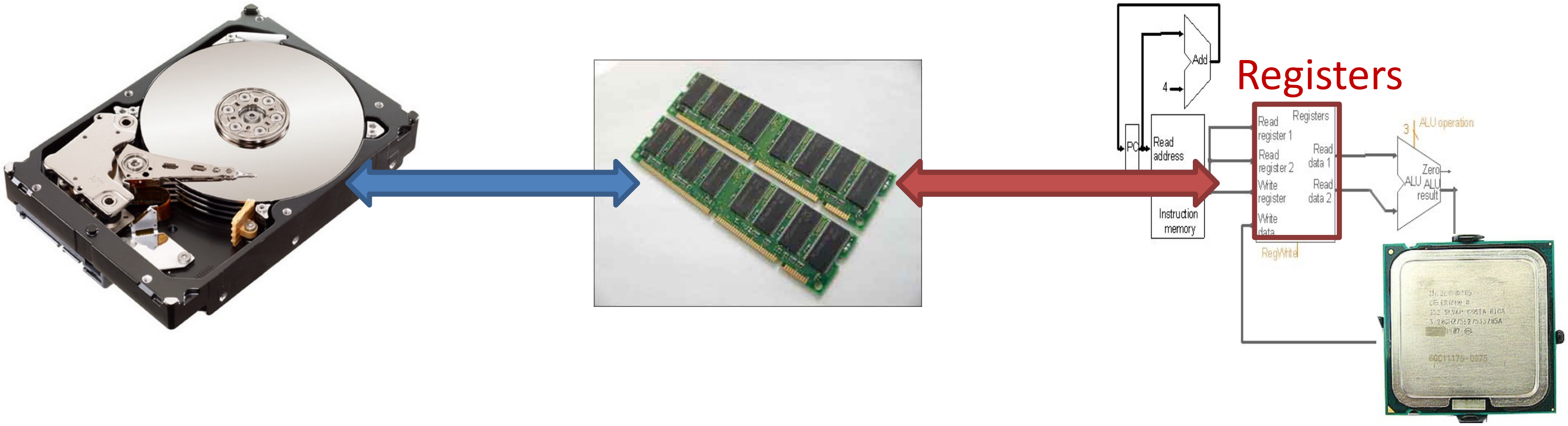
Running

Terminate

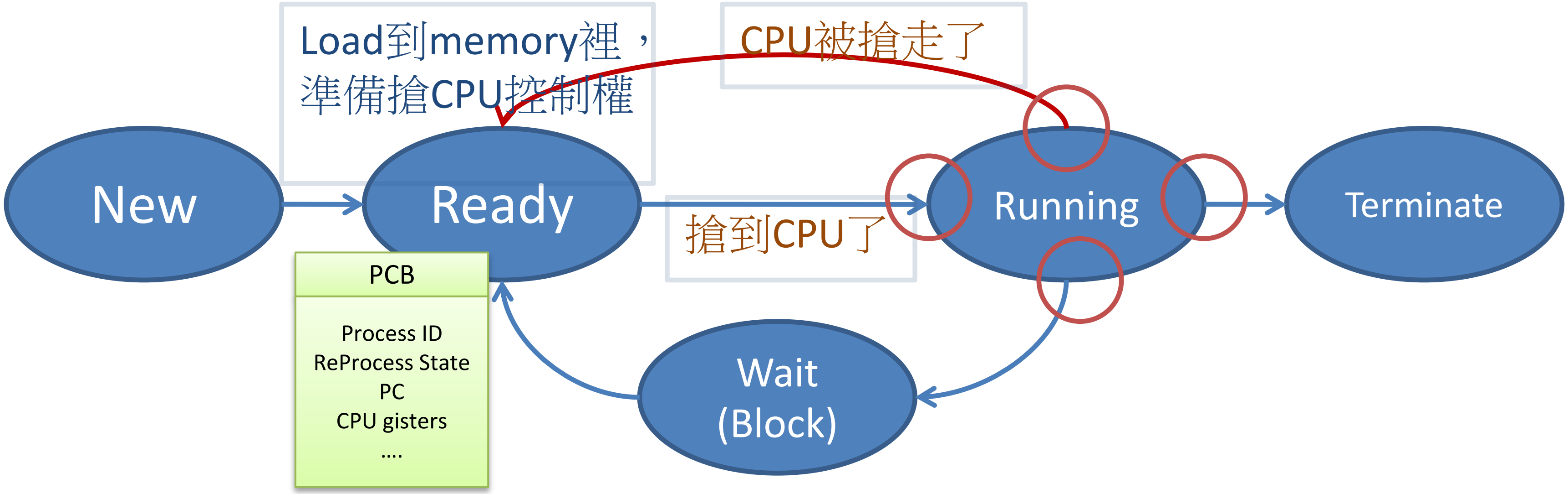
Wait (Block)

PCB

Process ID
ReProcess State
PC
CPU gisters
....



Registers



Load到memory裡，準備搶CPU控制權

CPU被搶走了

New

Ready

搶到CPU了

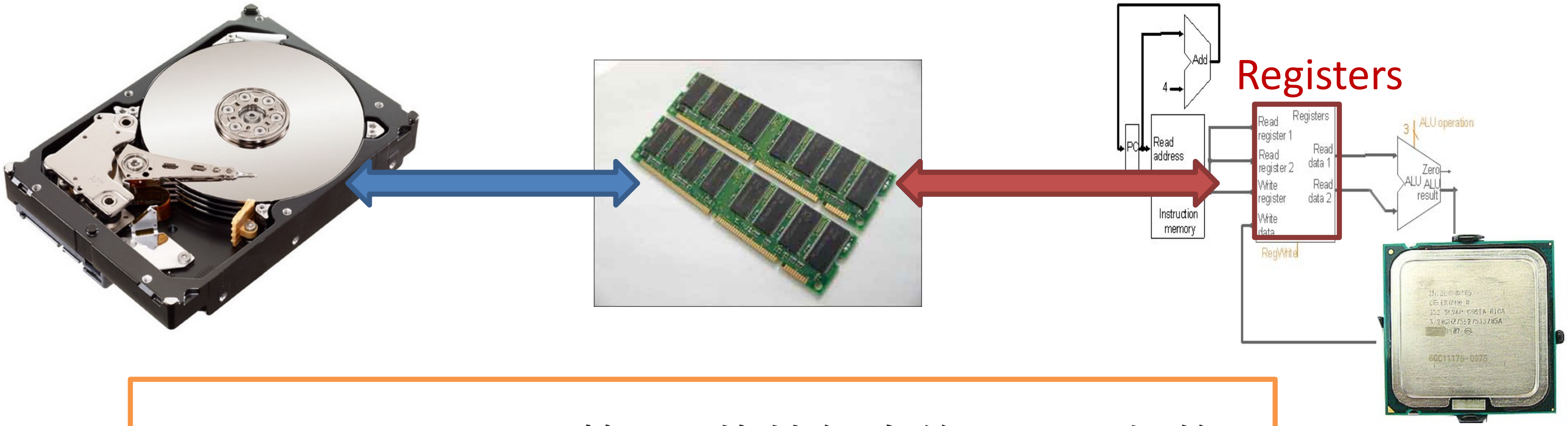
Running

Terminate

Wait (Block)

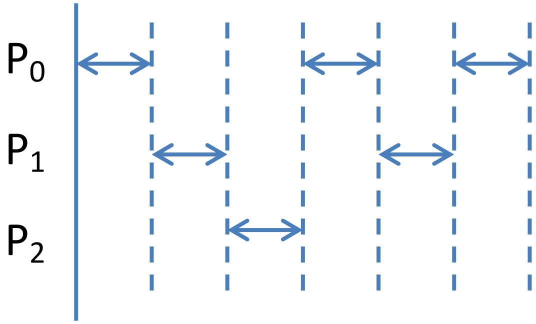
PCB

Process ID
ReProcess State
PC
CPU gisters
….

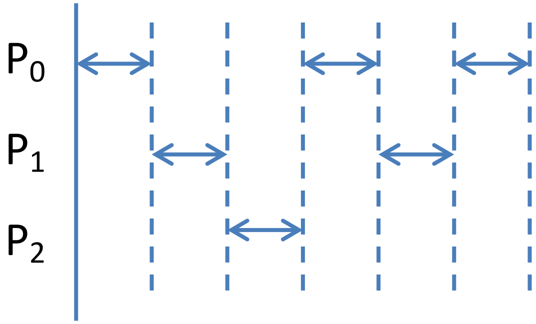


Context Switching：若CPU將執行中的Process切換給其他Process使用時，必須保存目前執行中Process的狀態，並載入欲執行Process的狀態資訊。

問題是搬家是需要成本的…

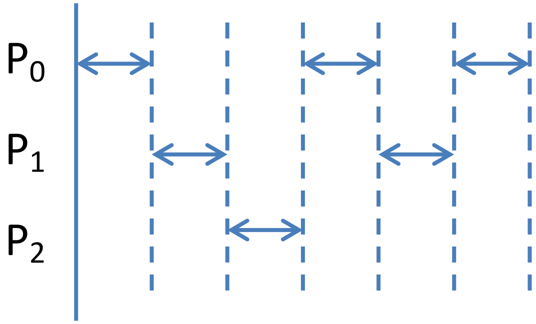


問題是搬家是需要成本的…



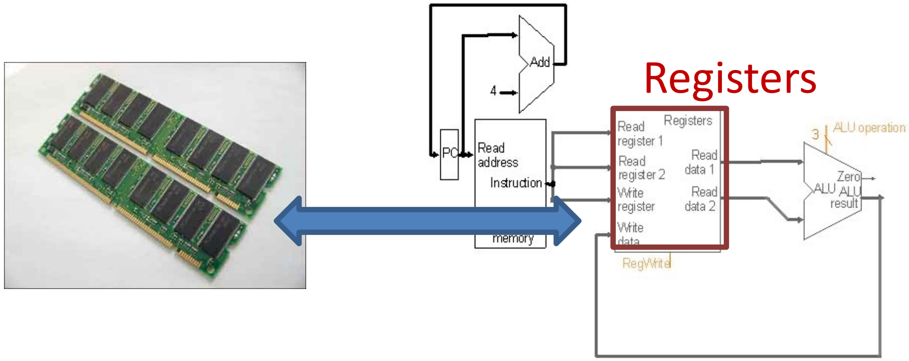
太多Process並行效能反而不如預期…

問題是搬家是需要成本的…

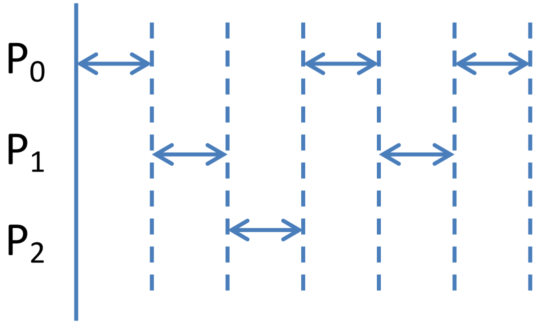


太多Process並行效能反而不如預期…

解法1：提供多套Registers

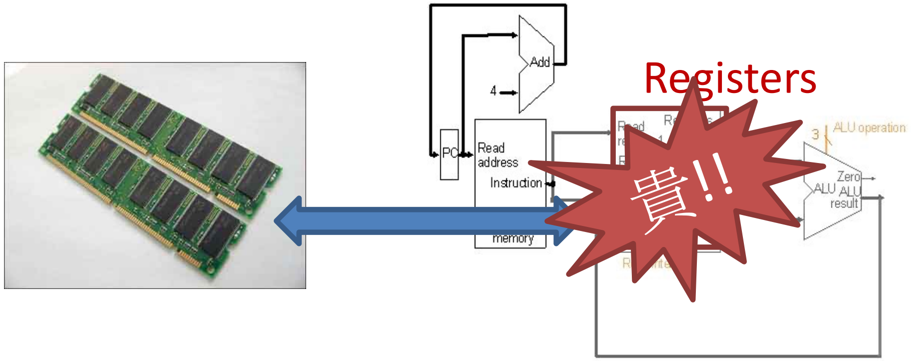


問題是搬家是需要成本的...

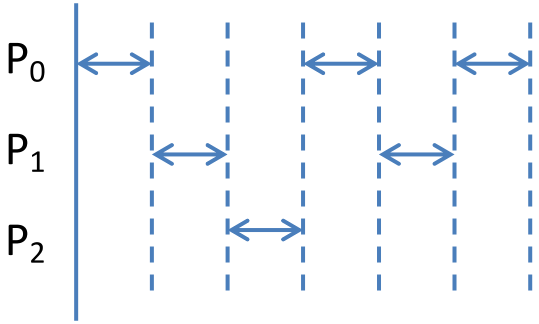


太多Process並行效能反而不如預期...

解法1：提供多套Registers



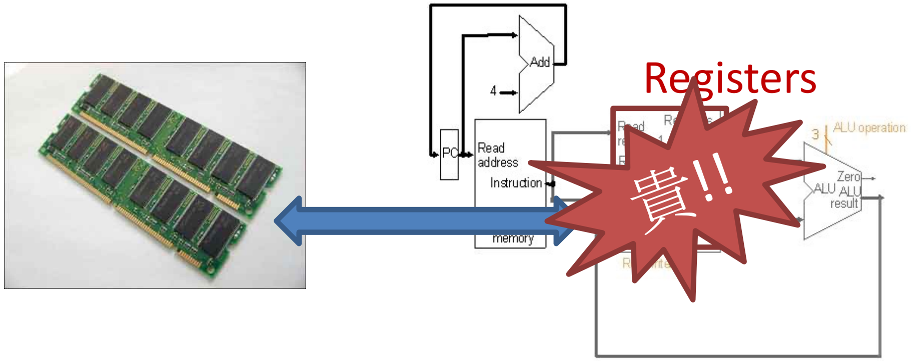
問題是搬家是需要成本的...



太多Process並行效能反而不如預期...

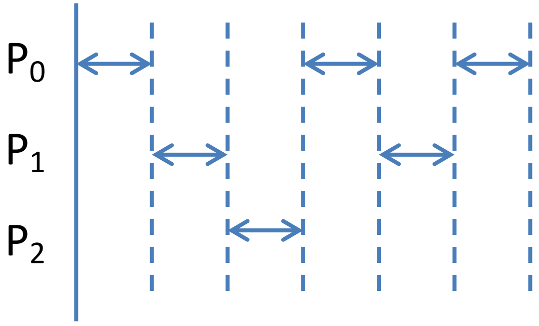
解法1：提供多套Registers

解法2：改用Thread~



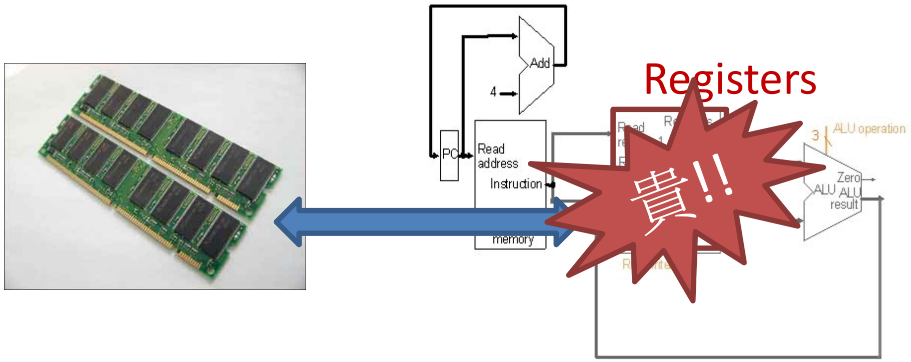
Thread: Light weight process. 是CPU分配資源的最小單位，而同一個Process內的threads共享code section, data section, 跟一些OS資源

問題是搬家是需要成本的…



太多Process並行效能反而不如預期…

解法1：提供多套Registers



解法2：改用Thread~

Thread: Light weight process. 是CPU分配資源的最小單位，而同一個Process內的threads共享code section, data section, 跟一些OS資源

context switching 的負擔較小

建立Thread也是有成本的

→ 用空間換取時間~~

建立Thread也是有成本的

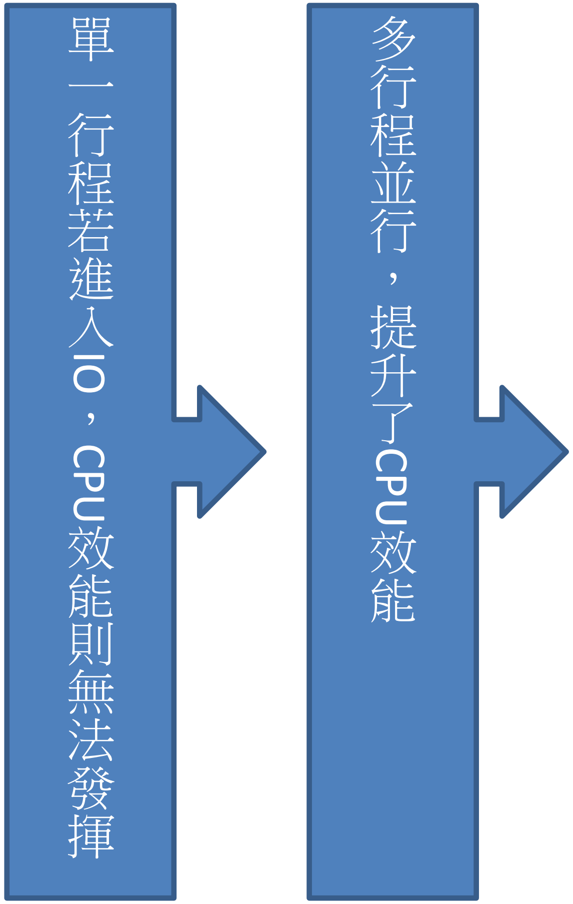
→ 用空間換取時間~~

Thread Pool: 在Process建立之初，預先建立多條threads置於thread pool中，當需要使用時，就從thread pool中取出使用，用完再還給thread pool。

到目前為止…

單一行程若進入IO，CPU效能則無法發揮

到目前為止…



單一行程若進入IO，CPU效能則無法發揮

多行程並行，提升了CPU效能

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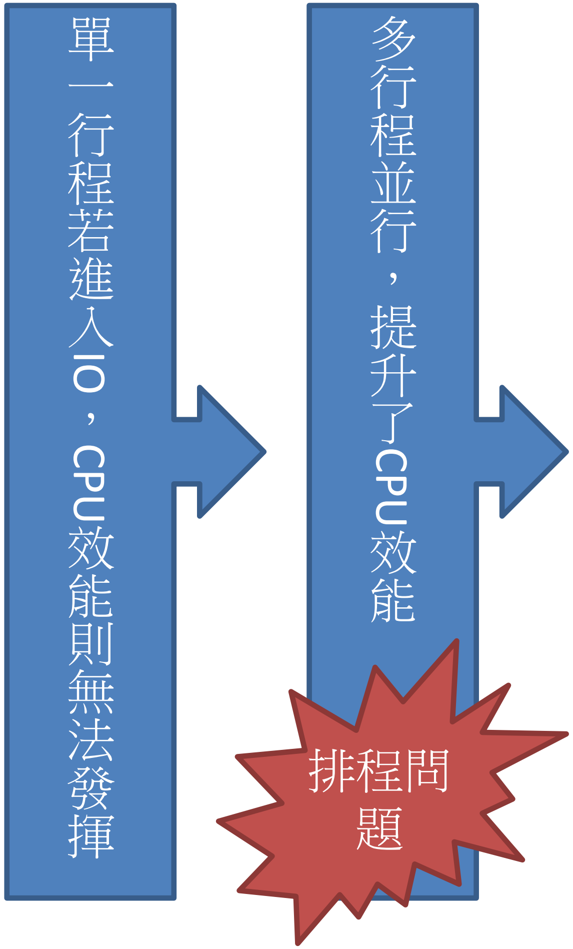

單一行程若進入IO，CPU效能則無法發揮

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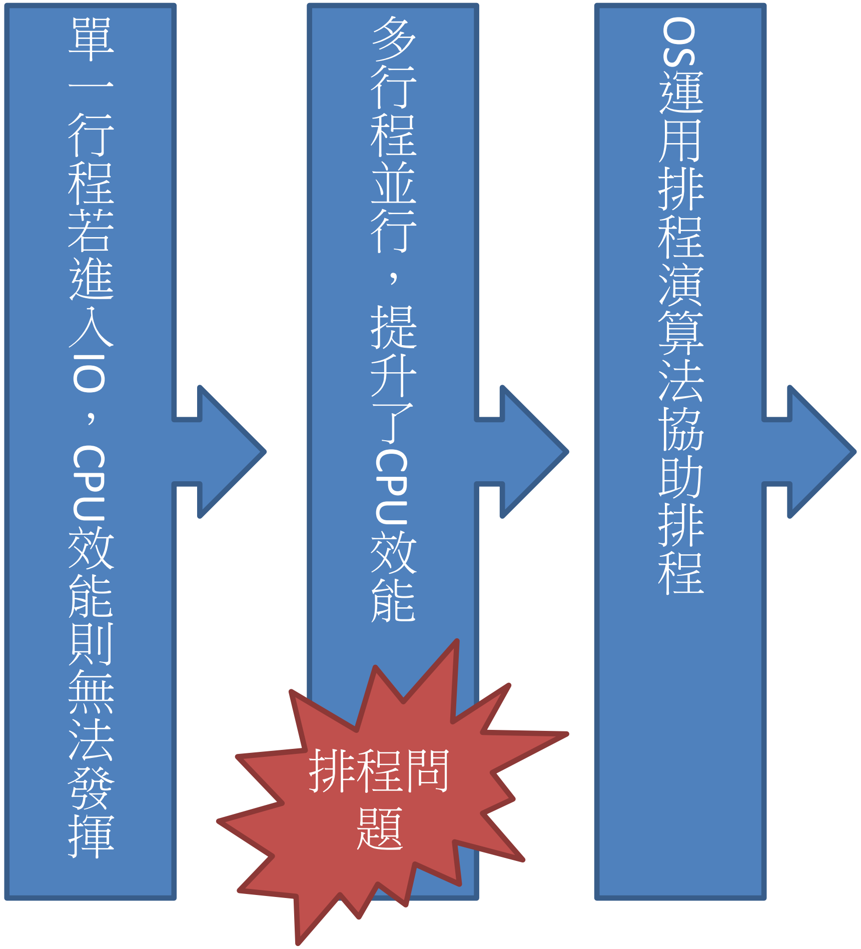
排程問題

到目前為止…



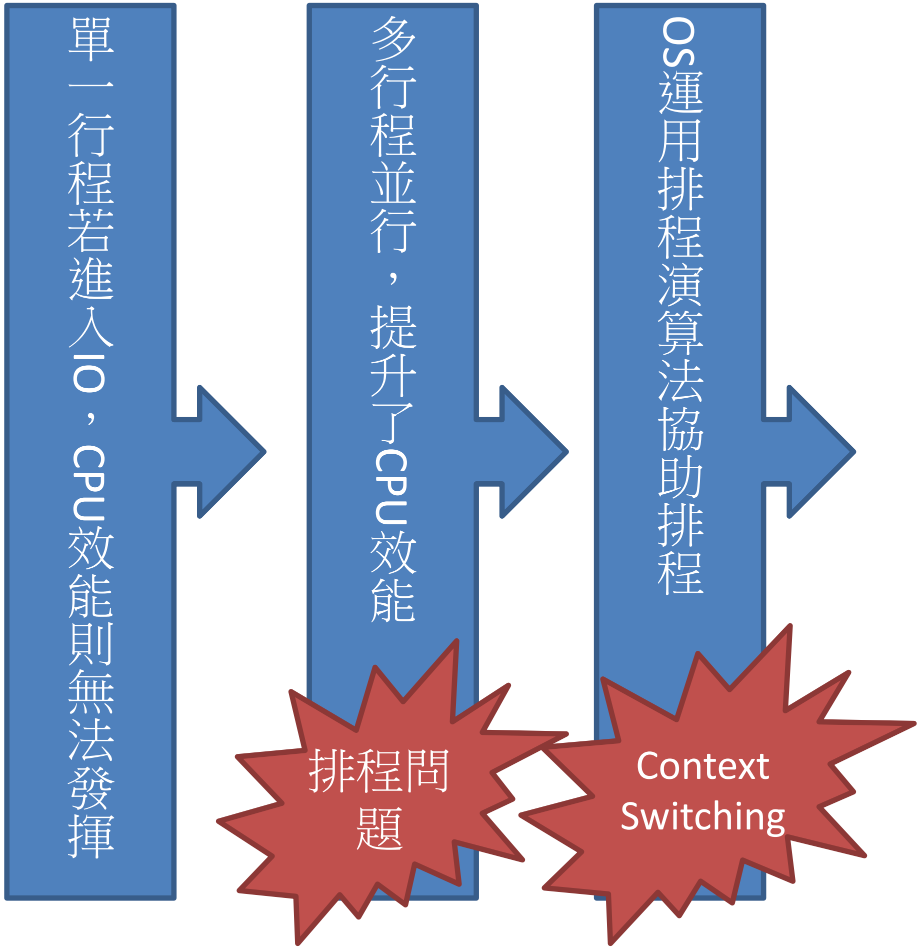
單一行程若進入IO，CPU效能則無法發揮

多行程並行，提升了CPU效能

排程問題

OS運用排程演算法協助排程

到目前為止…



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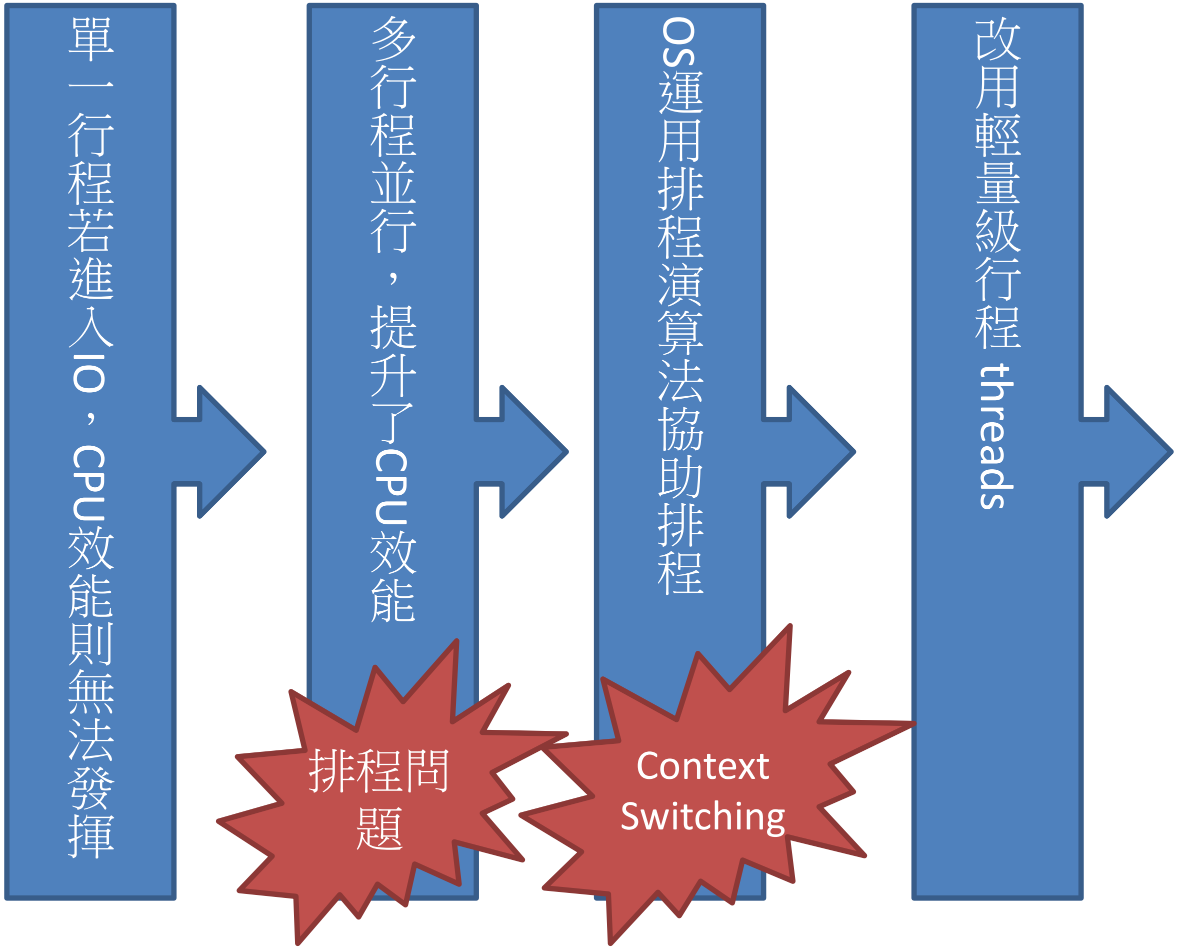
多行程並行，提升了CPU效能

OS運用排程演算法協助排程

排程問題

Context Switching

到目前為止…



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多行程並行，提升了CPU效能

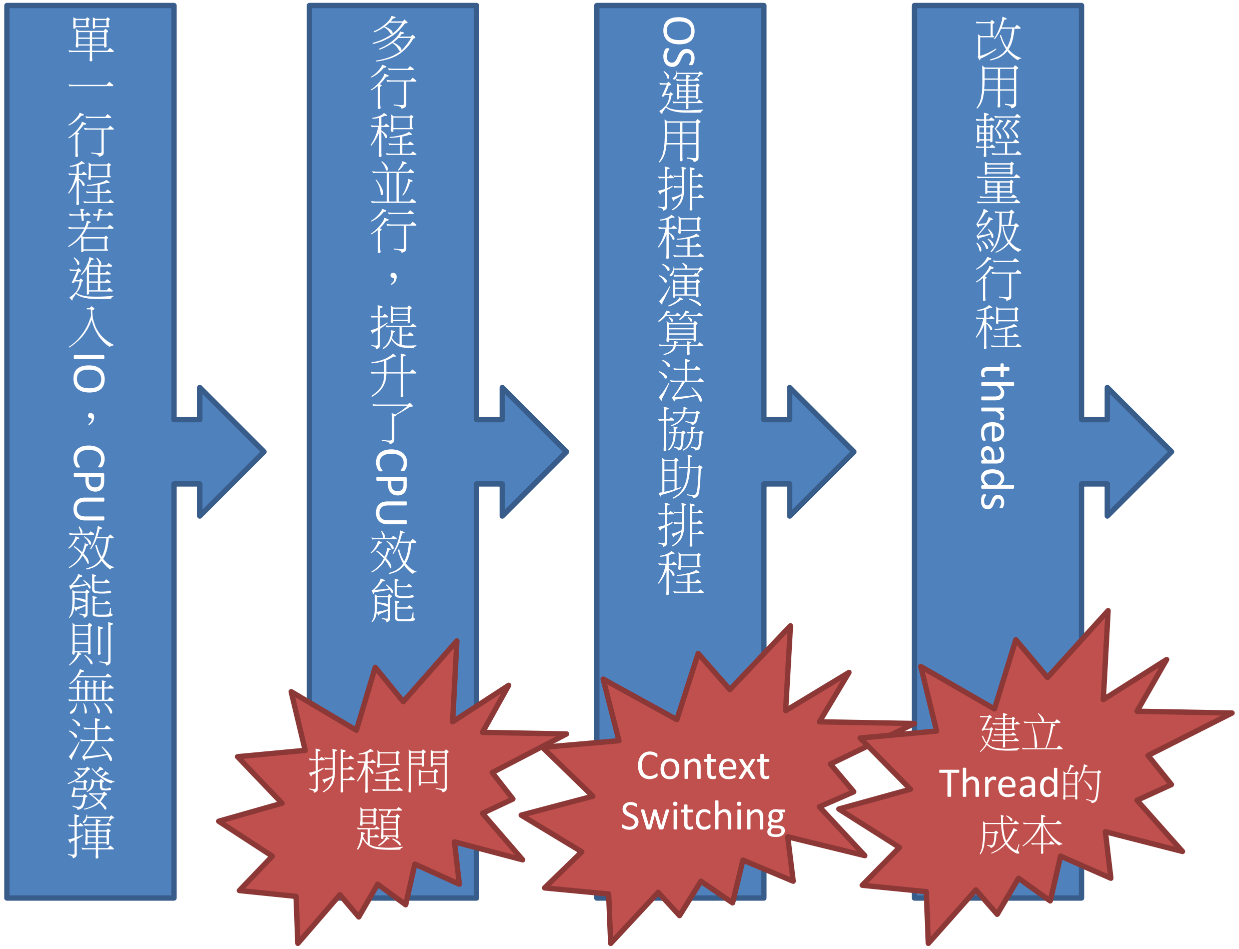
OS運用排程演算法協助排程

改用輕量級行程 threads

排程問題

Context Switching

到目前為止…



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多行程並行，提升了CPU效能

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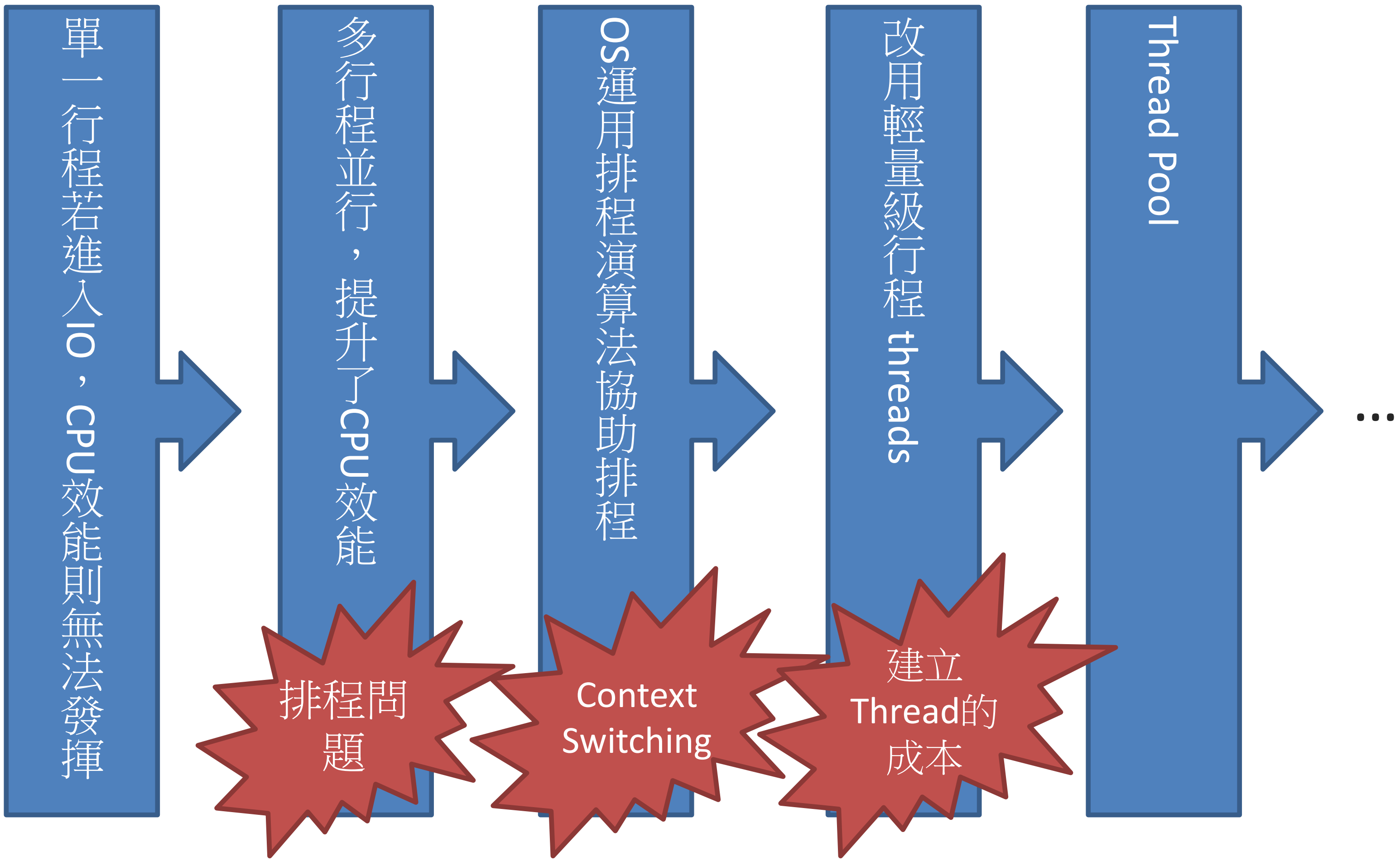
改用輕量級行程 threads

排程問題

Context Switching

建立Thread的成本

到目前為止…



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排程問題

OS運用排程演算法協助排程

Context Switching

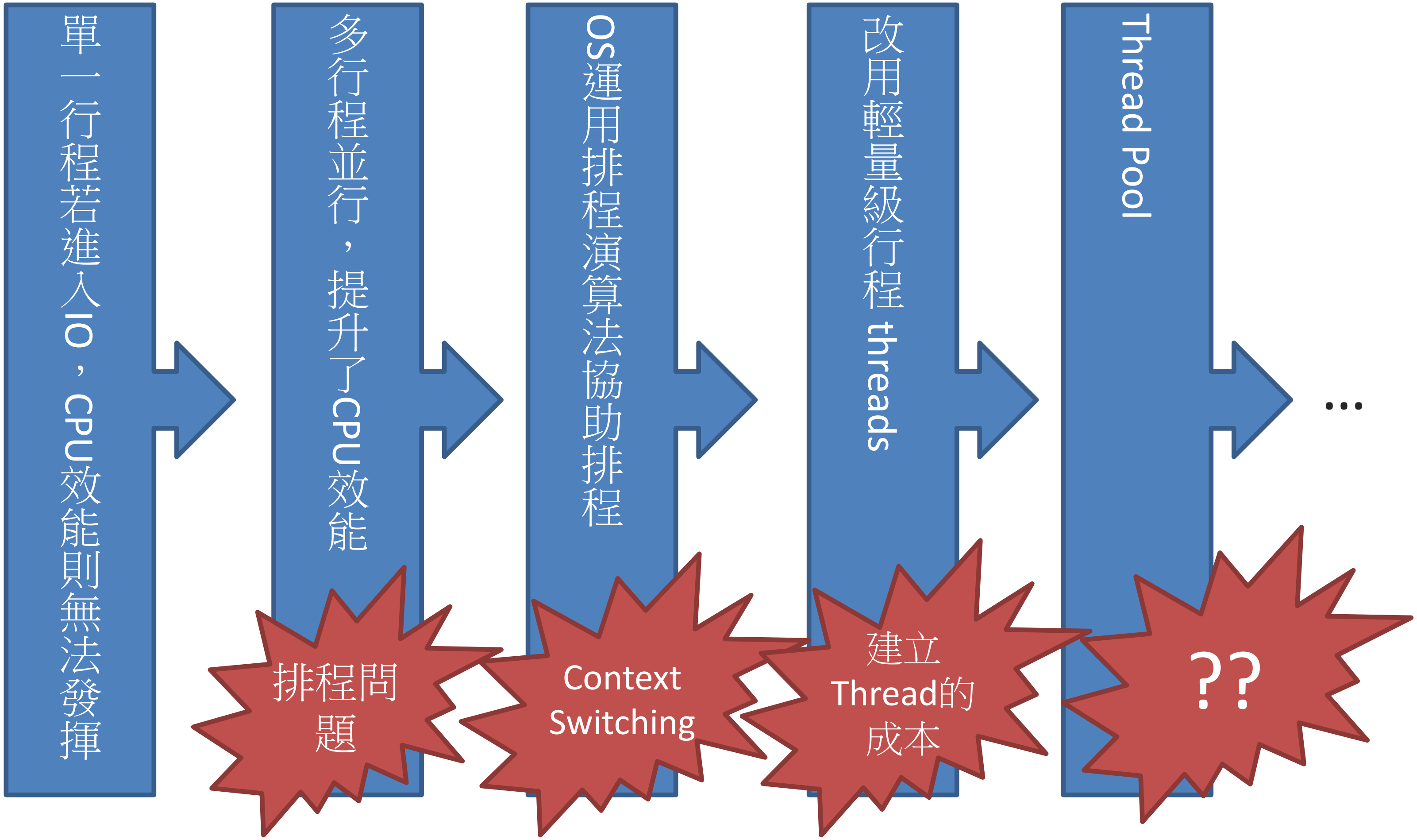
改用輕量級行程 threads

建立Thread的成本

Thread Pool

…

到目前為止…



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…

排程問題

Context Switching

建立Thread的成本

??

Multi-Processing / Multi-Threading (1)

- 系統的資源通常是有限的
  - CPU週期、記憶體空間、檔案、I/O Device…

當Process需要資源時…

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當Process需要資源時…

Process提出
Request

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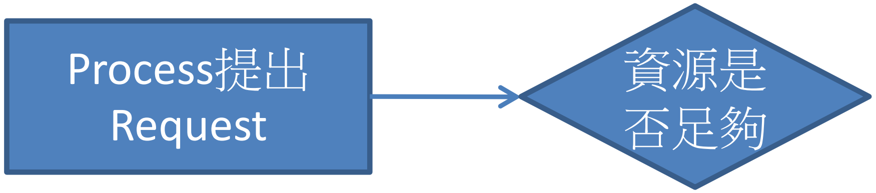

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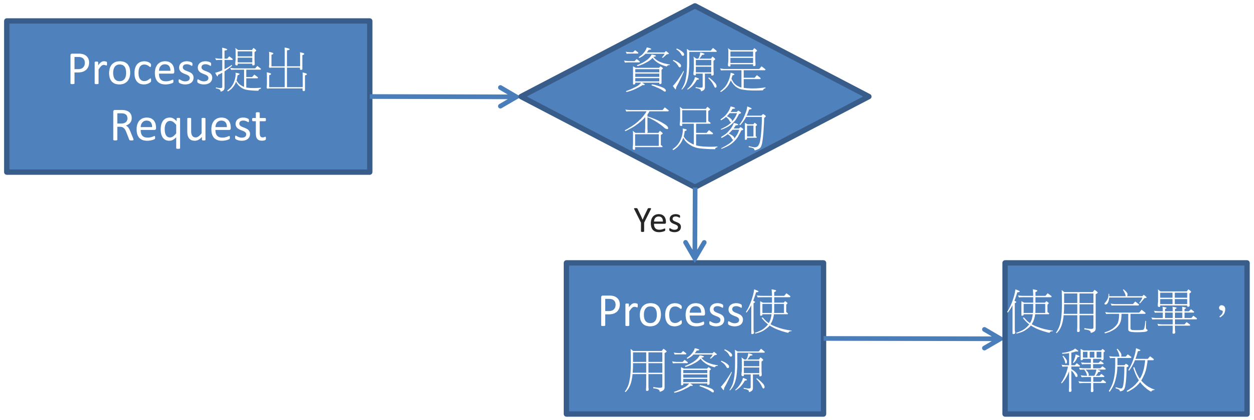

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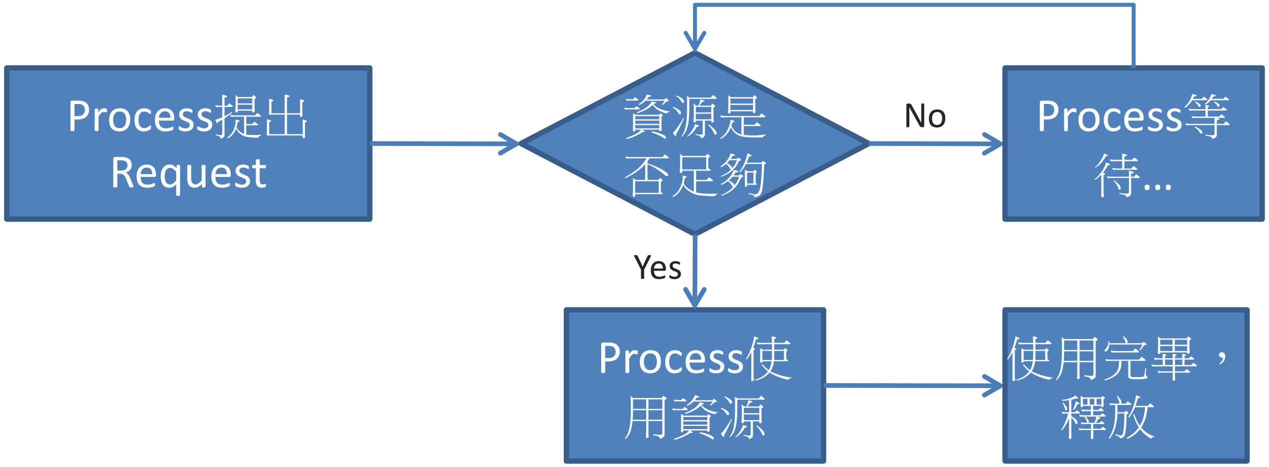

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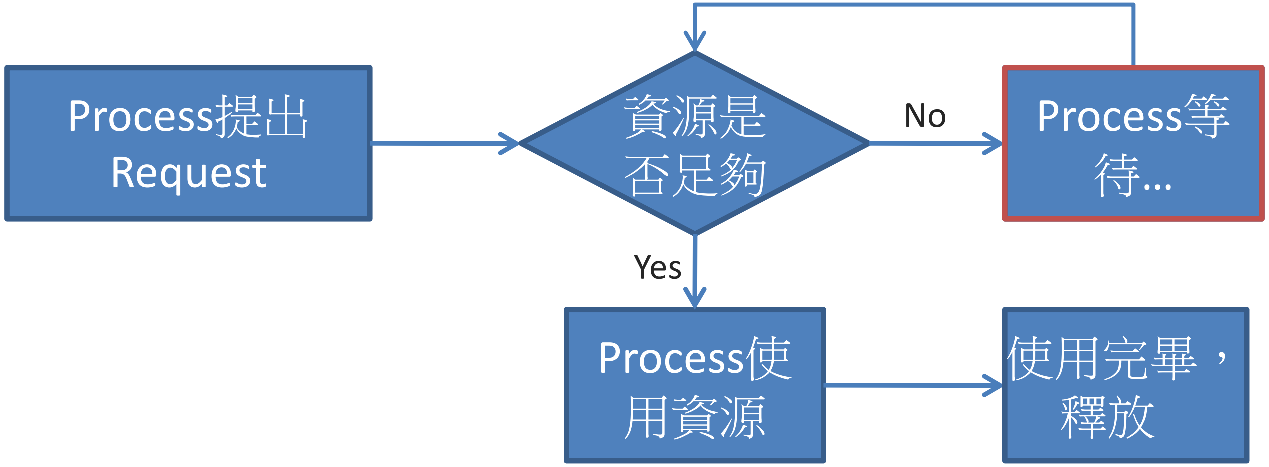


Process提出Request

資源是否足夠

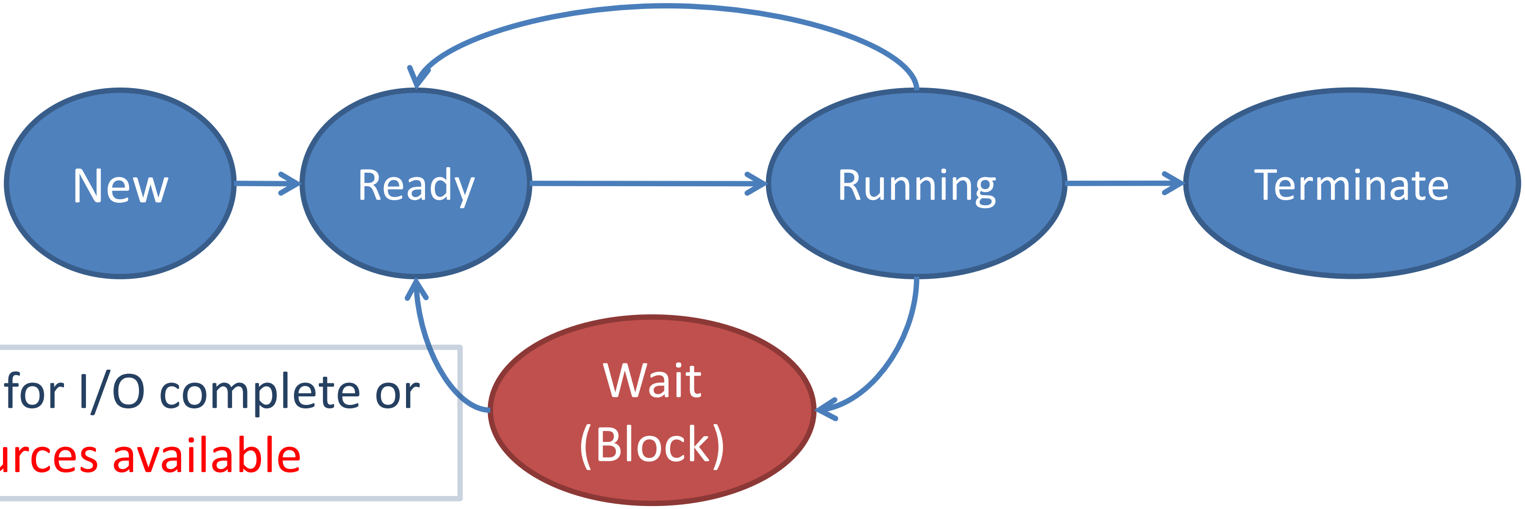
No

Process等待…

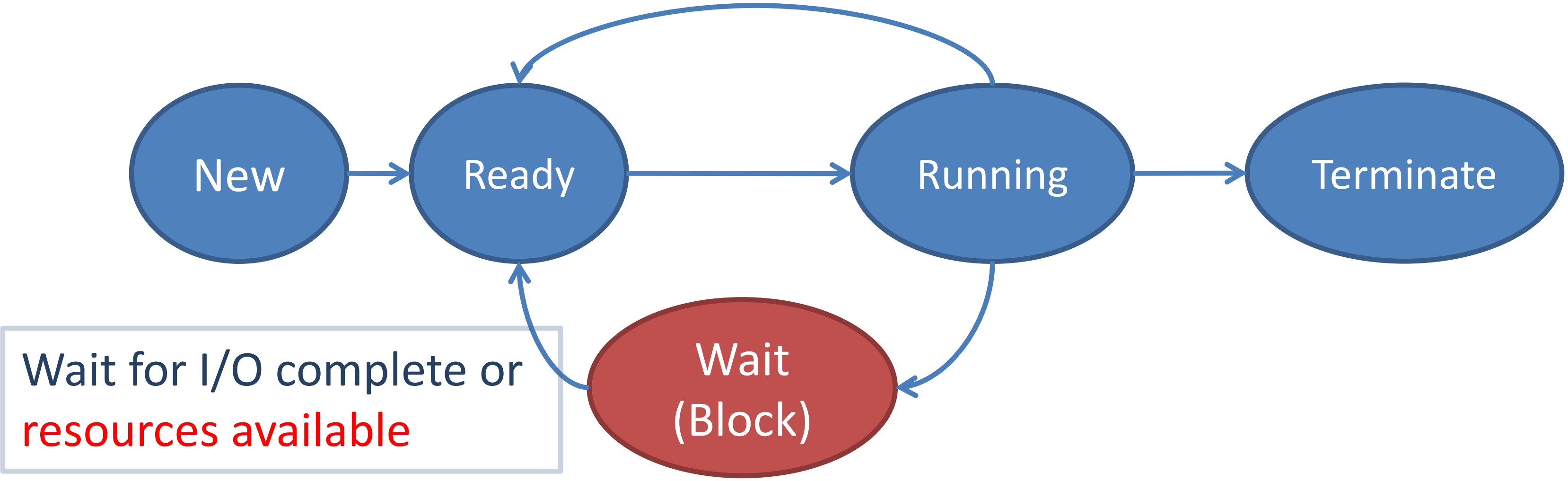
Yes

Process使用資源

使用完畢，釋放



Wait for I/O complete or resources available



New

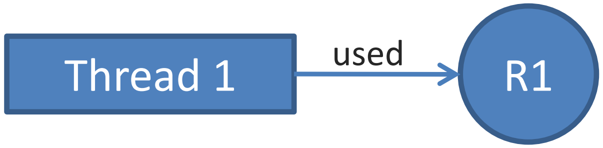
Ready

Running

Terminate

Wait (Block)

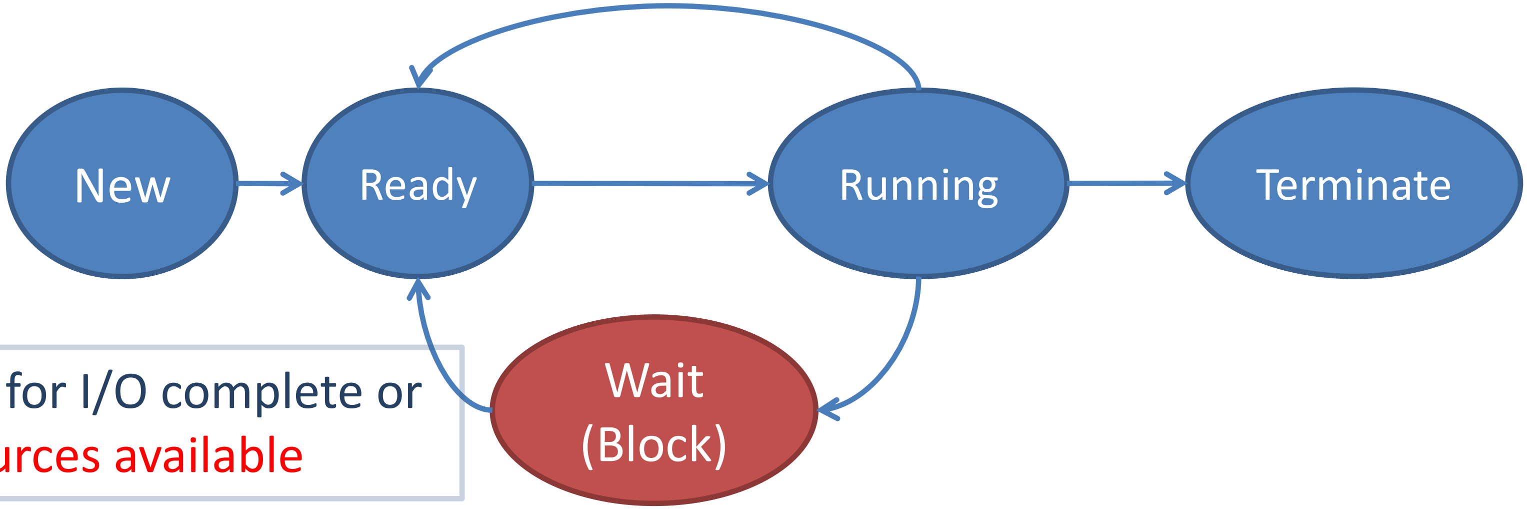
Wait for I/O complete or resources available



Thread 1

used

R1



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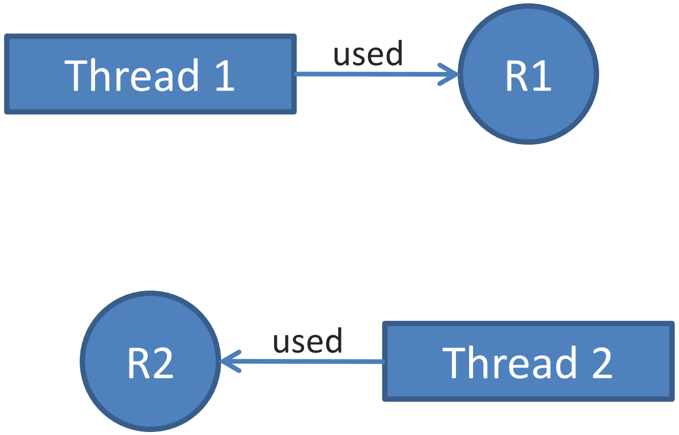

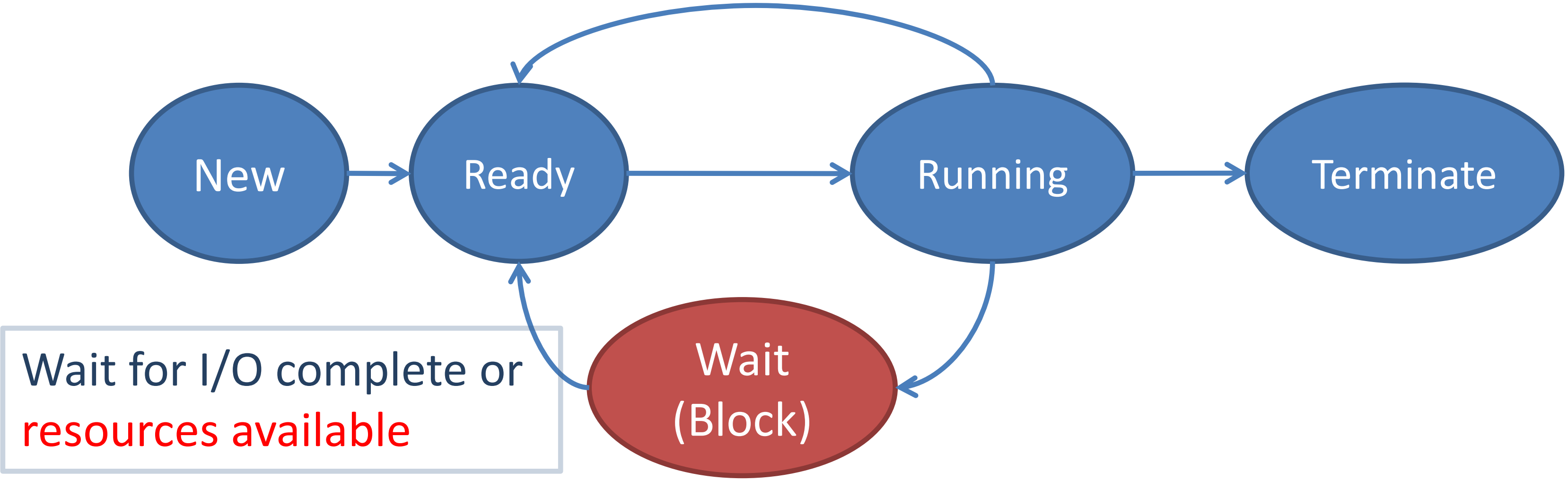

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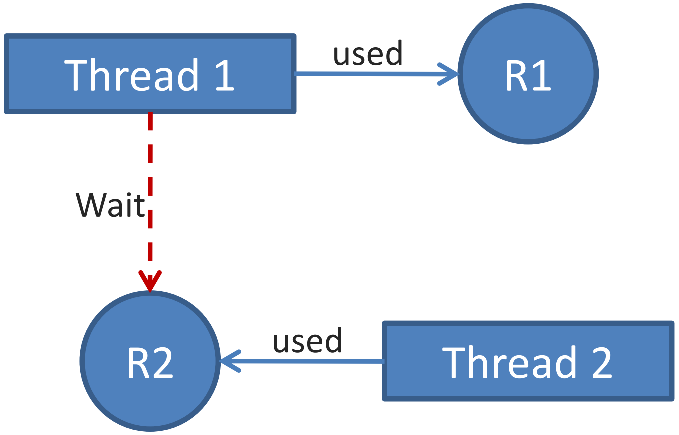

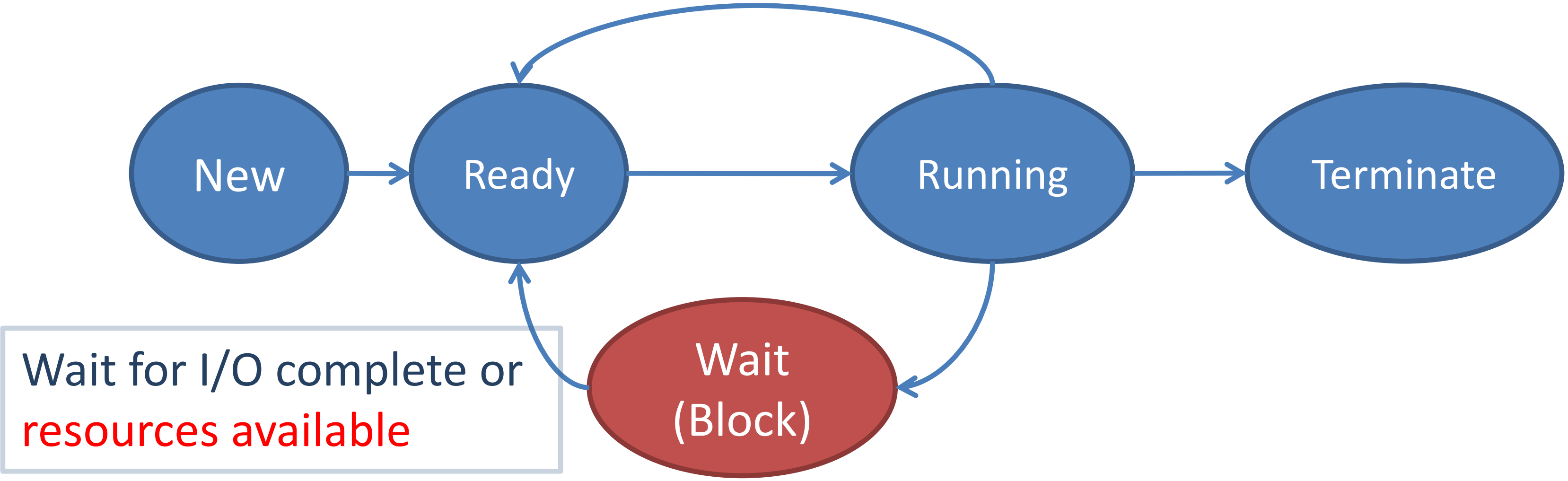

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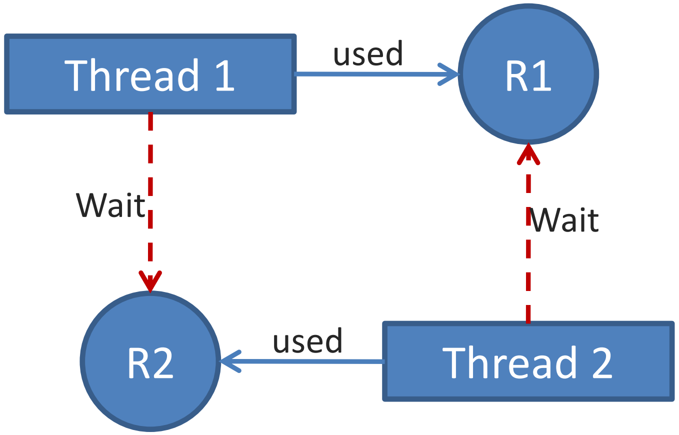

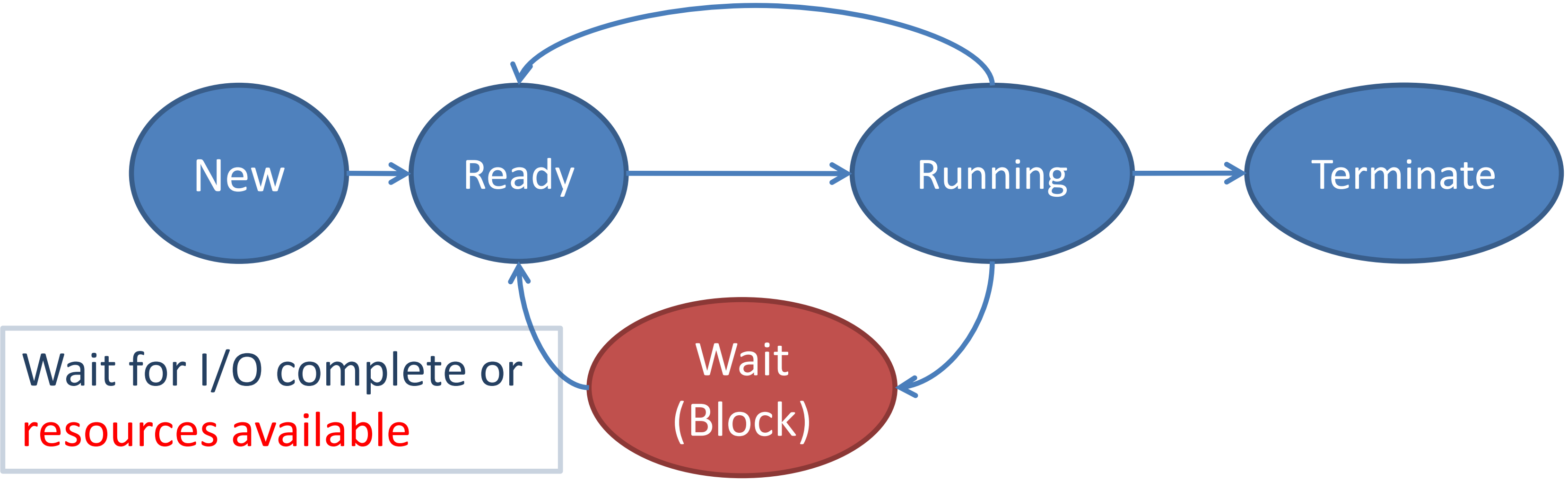

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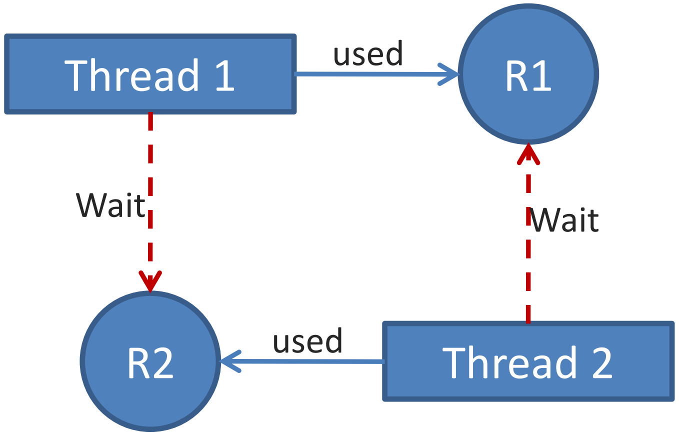
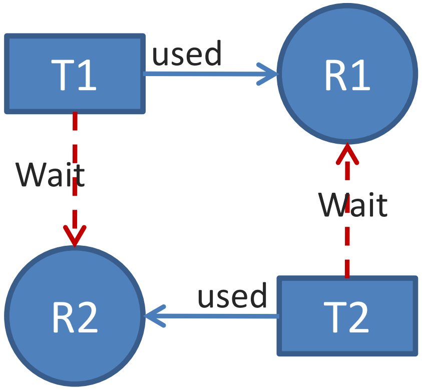


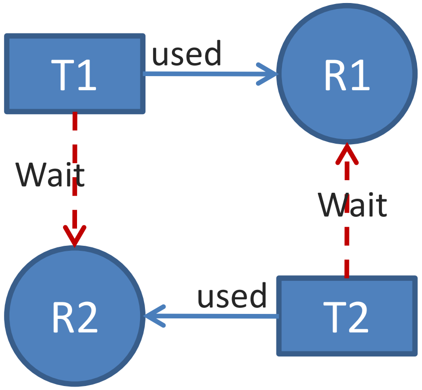
Deadlock: 系統中存在一組Processes，彼此形成circular waiting的情況，使得Processes皆無法繼續往下執行，導致CPU利用度及產能急速下降。

Deadlock 處理策略



Deadlock 處理策略

- Deadlock形成的必要條件：
  - 資源的Mutual Exclusion
  - Hold & Wait
  - No Preemptive
  - Circular waiting



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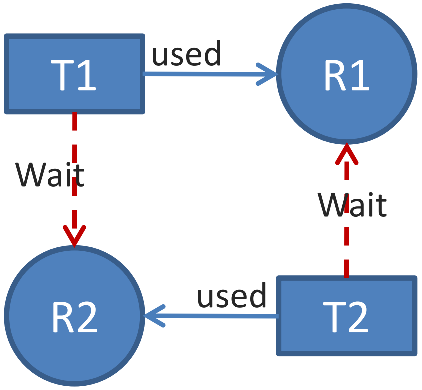

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  - Deadlock Prevention
  - Deadlock Avoidance
  - Deadlock Detection & Recovery

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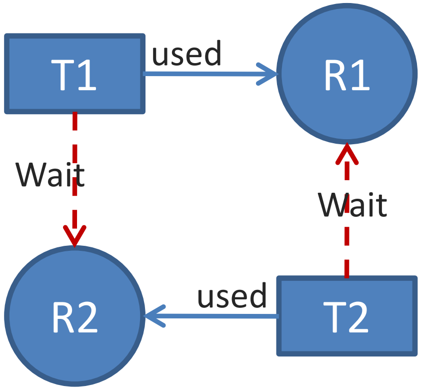

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預防勝於治療

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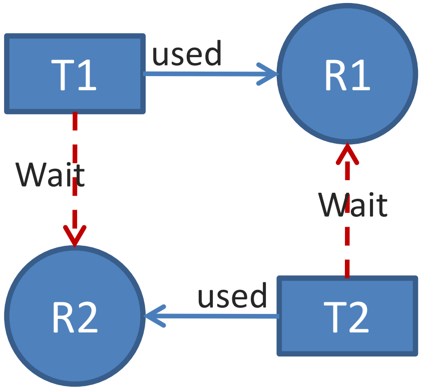


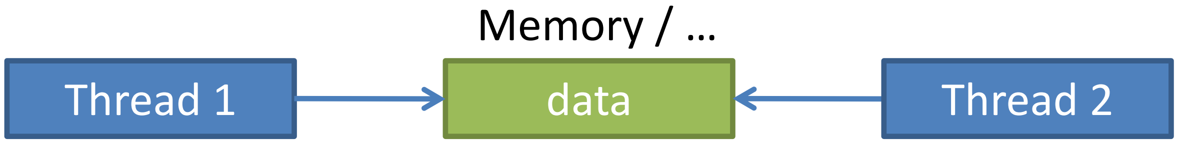
- 處理策略：
  - – Deadlock Prevention
  - – Deadlock Avoidance
  - – Deadlock Detection & Recovery

預防勝於治療

見到棺材才掉淚

Multi-Processing / Multi-Threading (2)

- Communication
  - Shared Memory



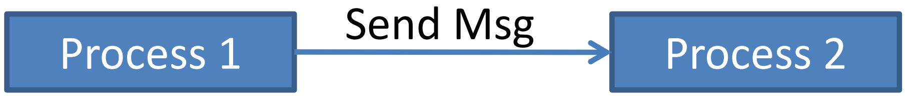
Memory / …

Thread 1

data

Thread 2

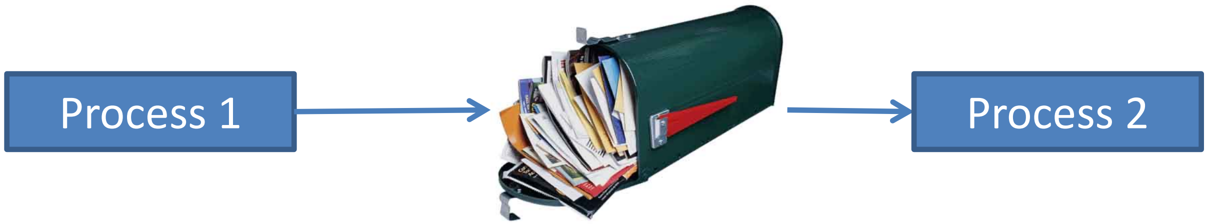
  - Message Passing



Process 1

Send Msg

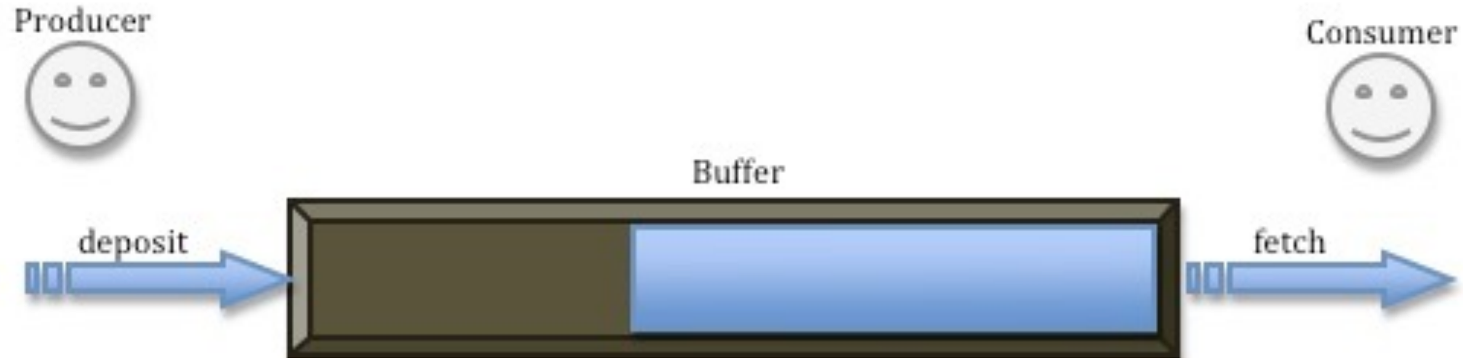
Process 2



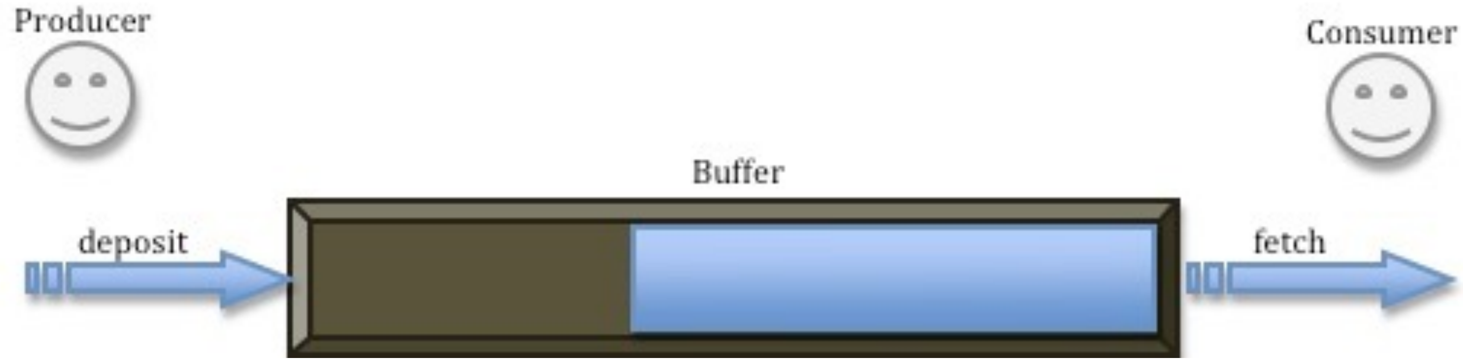
Process 1

Process 2

Producer & Consumer



Producer & Consumer

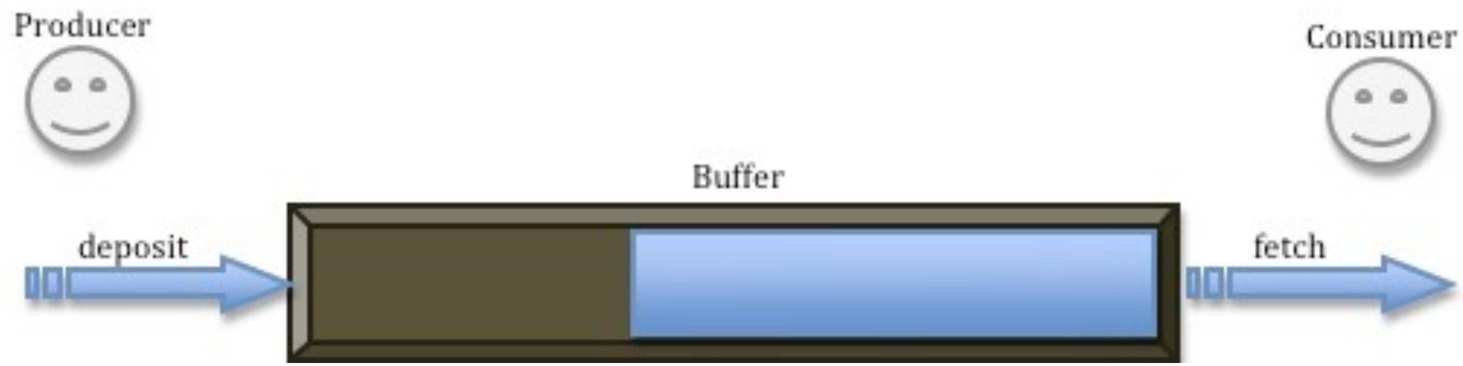


Bounded buffer Producer/Consumer Problem:

(1) 當Buffer滿時，則Producer必須等待。

(2) 當Buffer空時，則Consumer必須等待。

Producer & Consumer



Bounded buffer Producer/Consumer Problem:

(1) 當Buffer滿時，則Producer必須等待。

(2) 當Buffer空時，則Consumer必須等待。

→ 採用一個共用變數count來記錄buffer裡item的個數

Producer:

```
   生產一個item;
   while(count==size)
     do no-op;
   buffer[in] = item;
   in = (in+1) % size;
   count = count+1;
```

Consumer:

```
 while(count==0)
    do no-op;
 item = buffer[out];
 out = (out+1)  mod size;
 count = count-1;
```

Producer:

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   生產一個item;
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1. Producer跟 Consumer是concurrent的
2. 共享count變數

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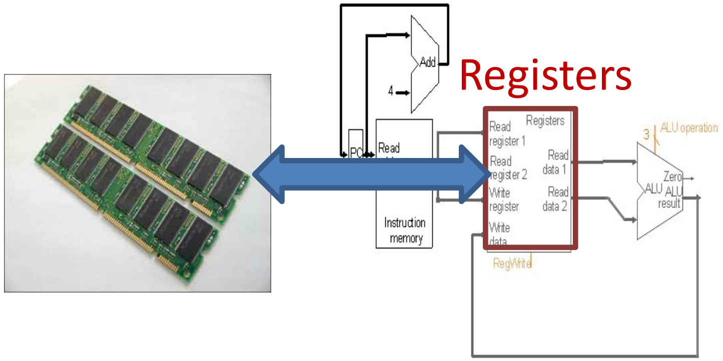
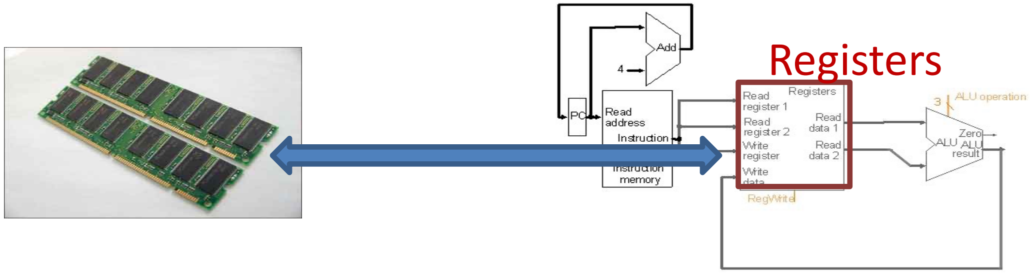
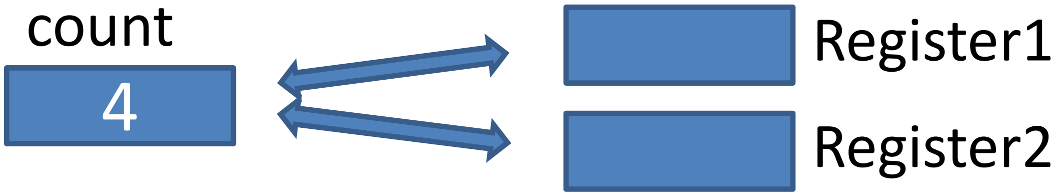




1. Producer跟 Consumer是concurrent的
2. 共享count變數
3. CPU可被搶奪的 (e.g. SRJF)



count

4

Register1

Register2

Producer (Thread1)

`count = count+1;`

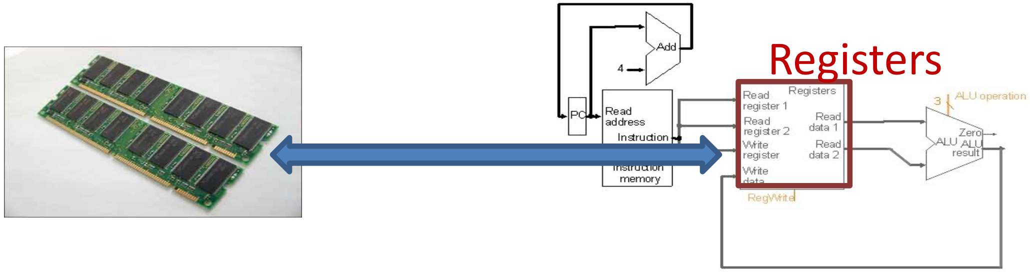
Register1 = count ...(1)
Register1 = Register1 + 1 ...(2)
count = Register1 ...(3)

Consumer (Thread2)

`count = count-1;`

Register2 = count ...(4)
Register2 = Register2 – 1 ...(5)
count = Register2 ...(6)

Not Atomic!!



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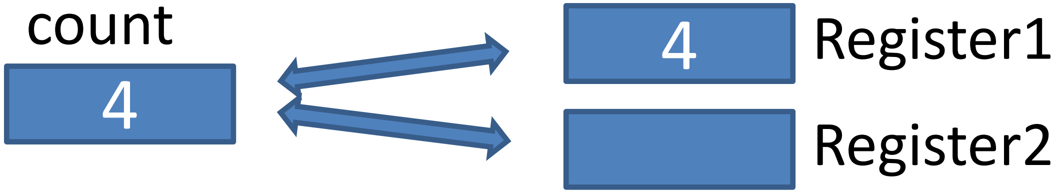

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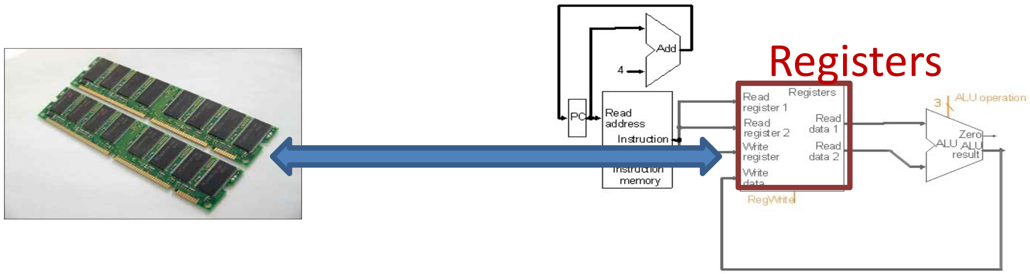

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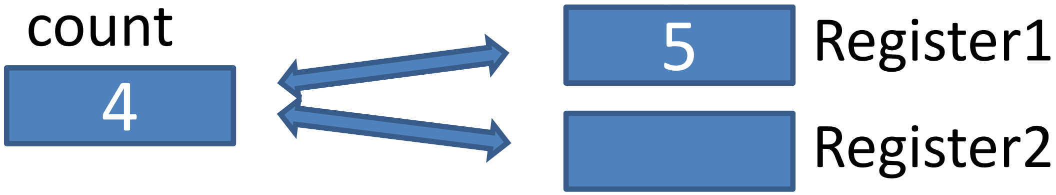

count

4

5 Register1

Register2

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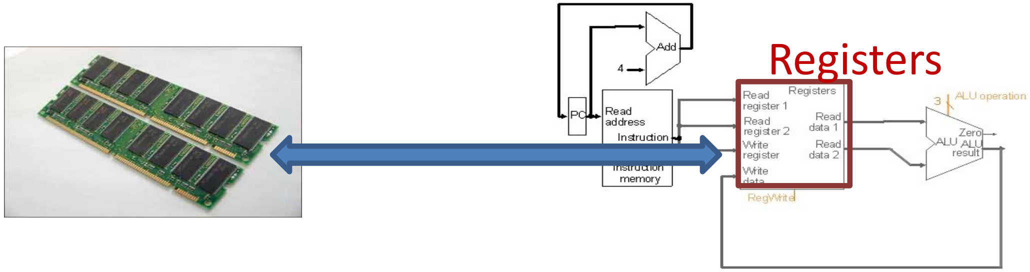

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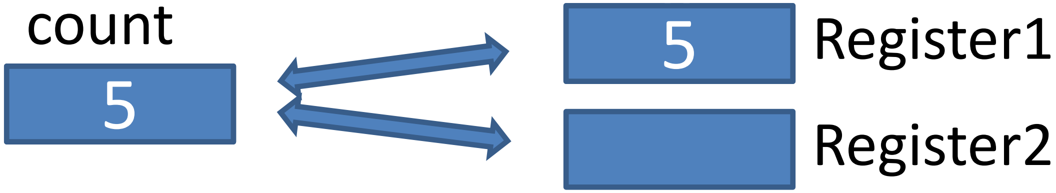

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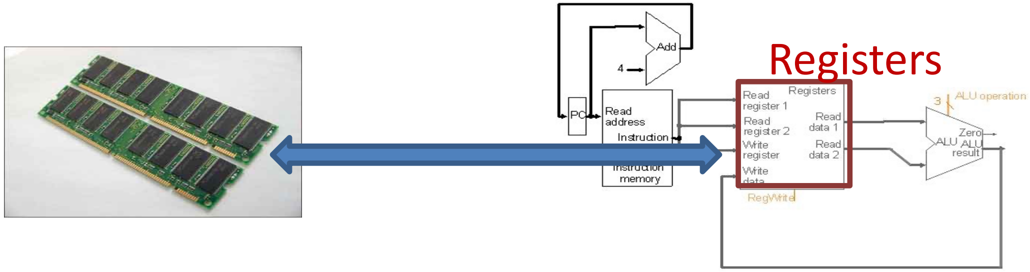

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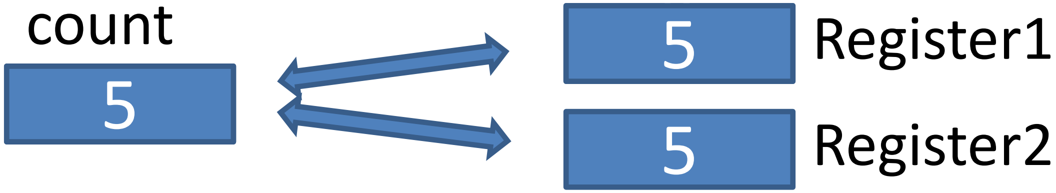

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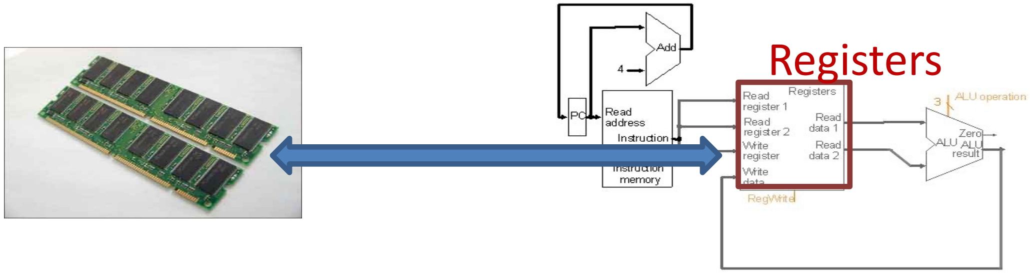

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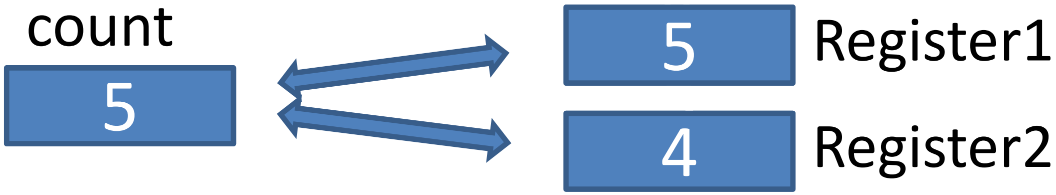

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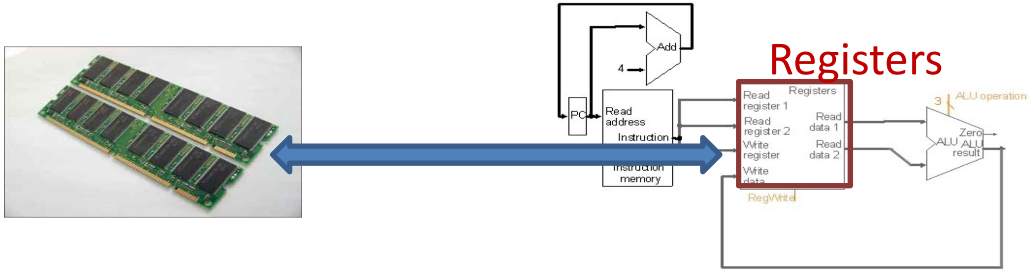

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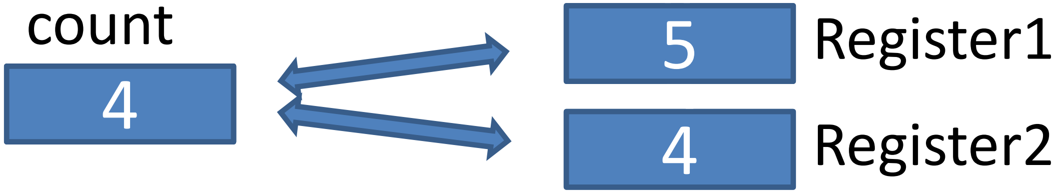

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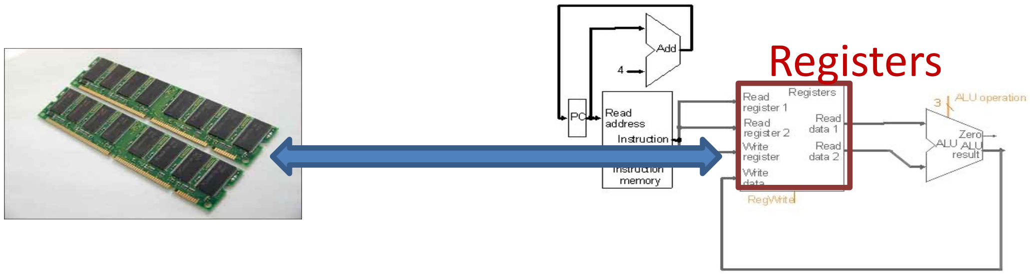

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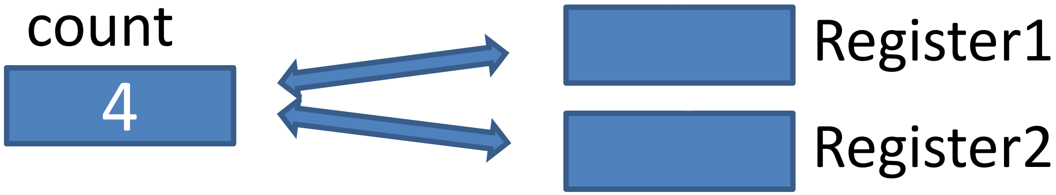

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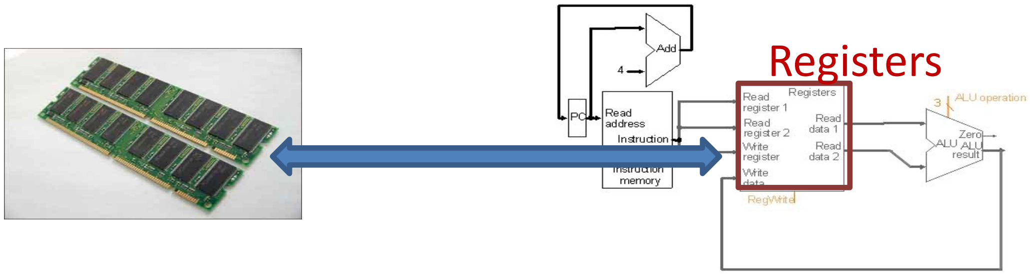

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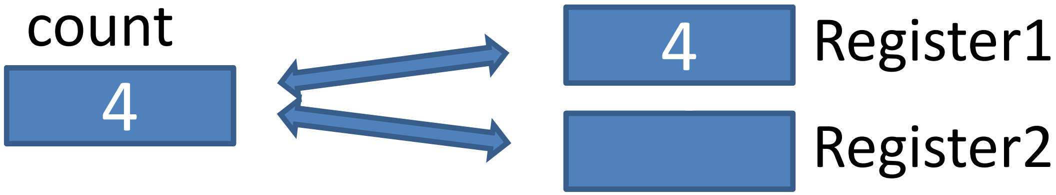

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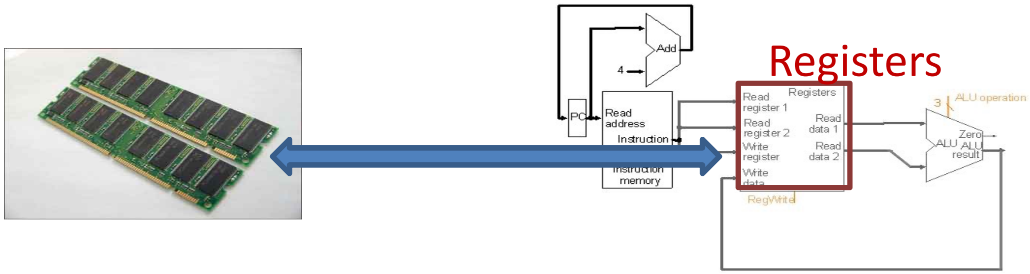

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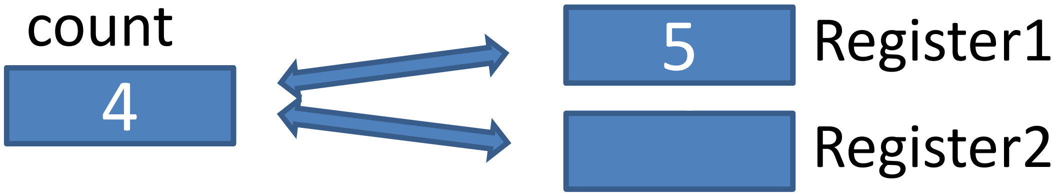

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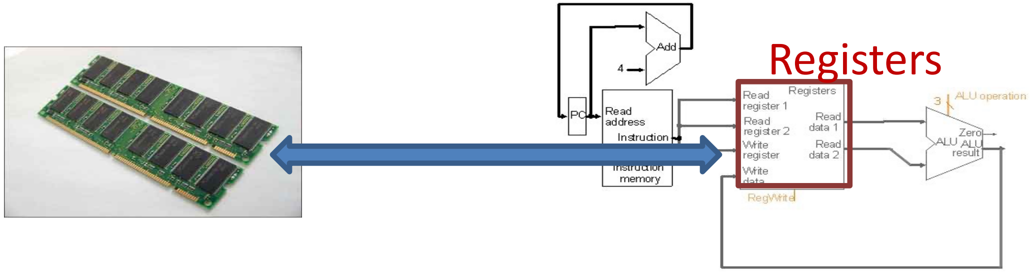

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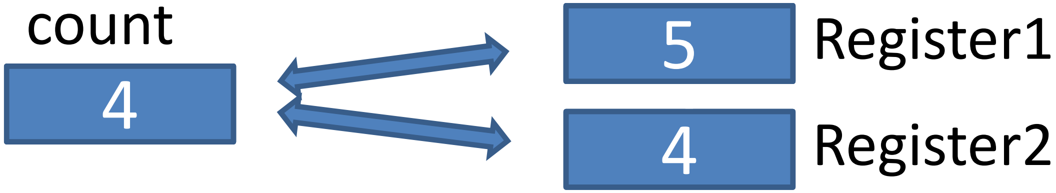

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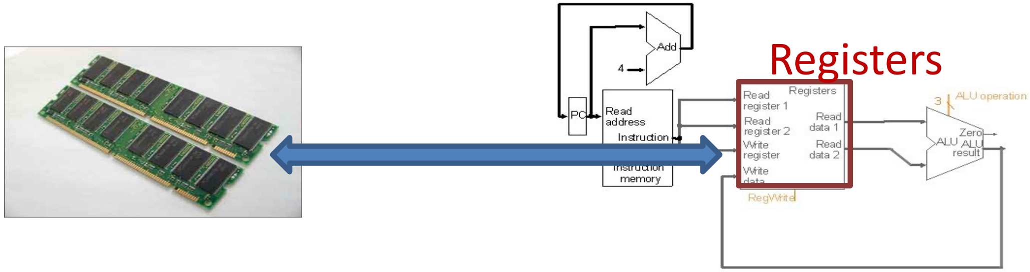

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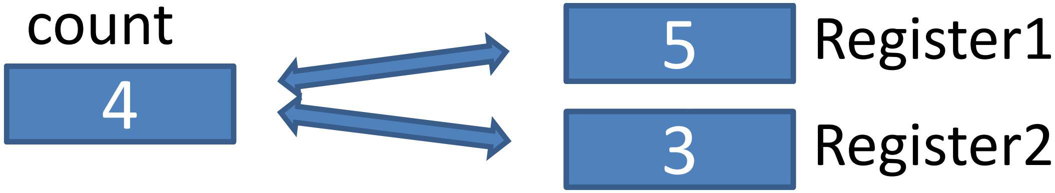

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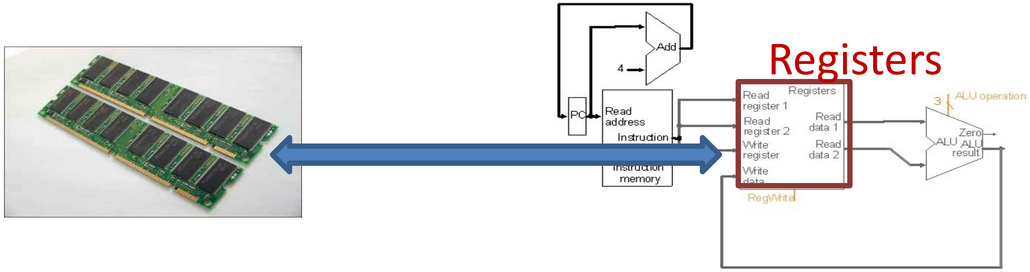

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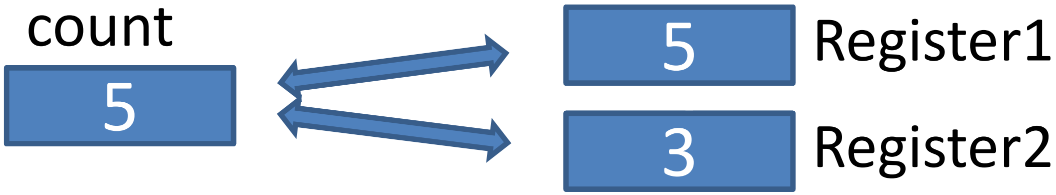

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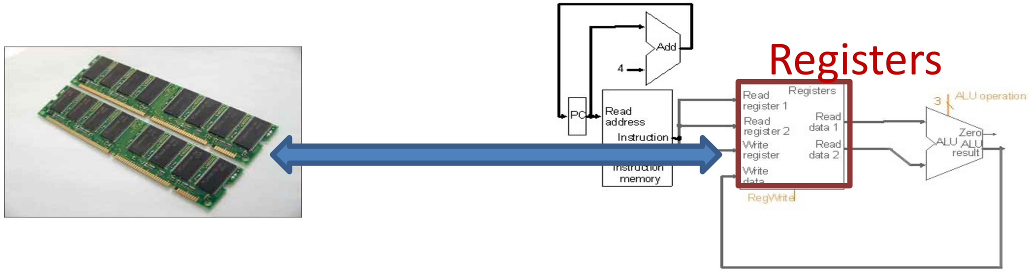

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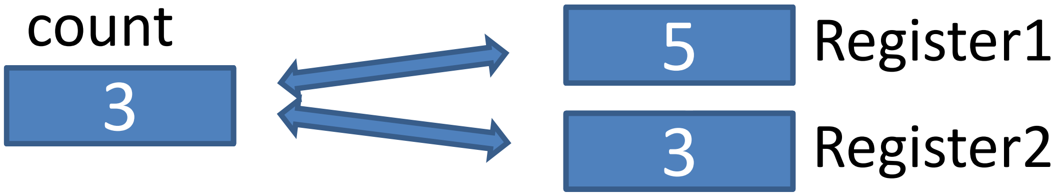
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5
Register1
3
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Race Condition

- 在Share Memory溝通方式下，共享變數的值會因為Processes執行的順序不同而有所不同。

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Producer
count = count+1;
```

```
Consumer:
count = count-1;
```

保證同一時間只有一個Process在存取共享變數

Critical Section

```
Repeat
    …
    Entry section
    C.S.
    Exit section
    …
Until false
```

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- Mutual Exclusion: 在任何時間點最多允許一個process在其C.S.內活動

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  - 在有限的時間內必須從想進入C.S.的processes中決定出一個Process進入C.S.

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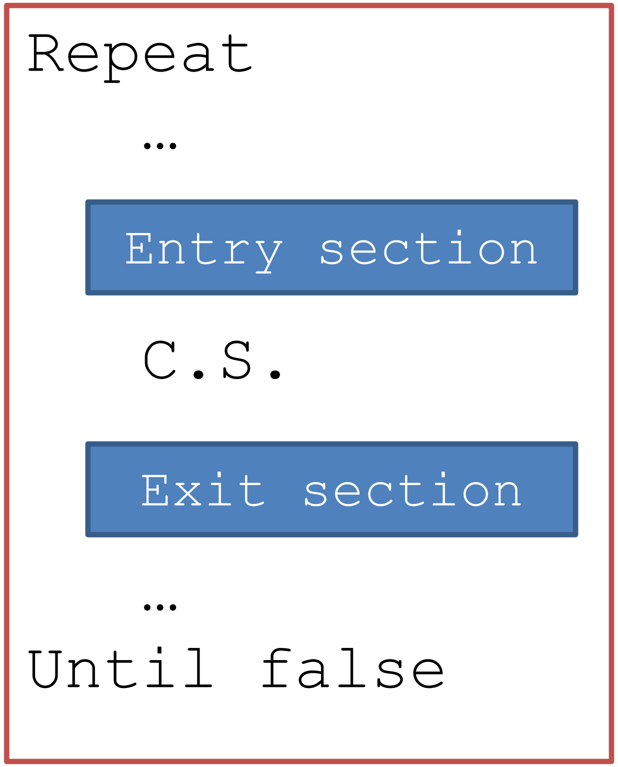

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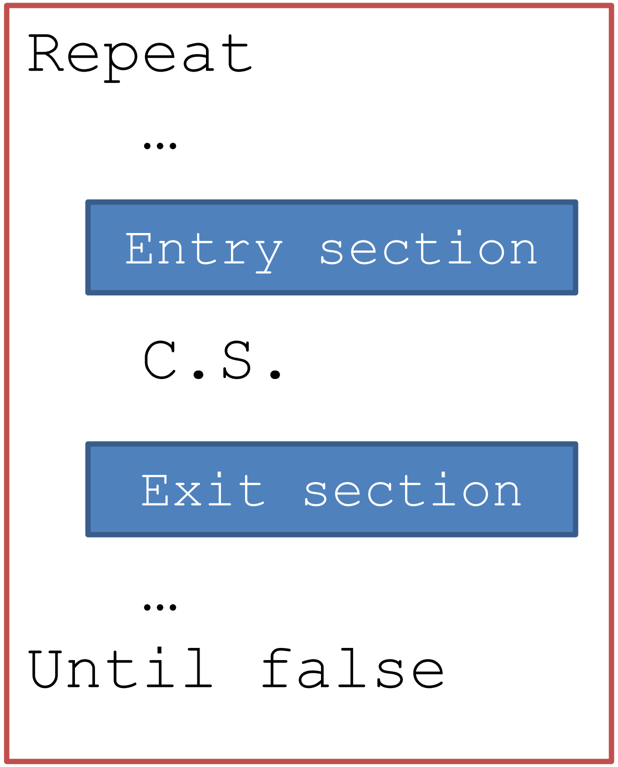

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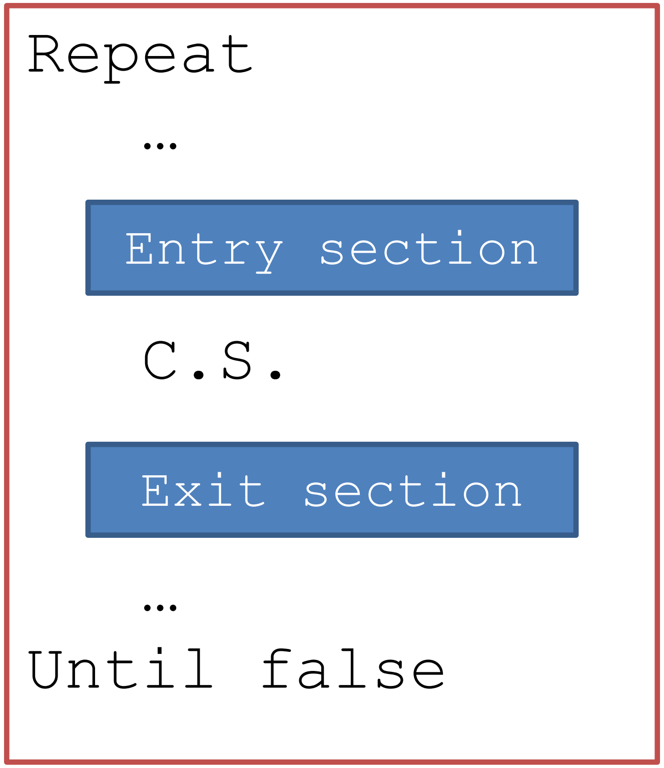
No Starvation

C.S. Design – design entry/exit section

- Software Solution
- Hardware Solution
- Semaphore
- Monitor
- Critical Region
- …



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Multi-Processing / Multi-Threading (3)

- 同步問題

如果我們希望A敘述
一定要在B敘述之前
執行，怎麼做？

P_1	P_2
…	…
A	B
…	…

Multi-Processing / Multi-Threading (3)

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Wait(s){
        while(s<=0) do no-op;
         s = s - 1;
}
```

```
Signal(s){
         s++;
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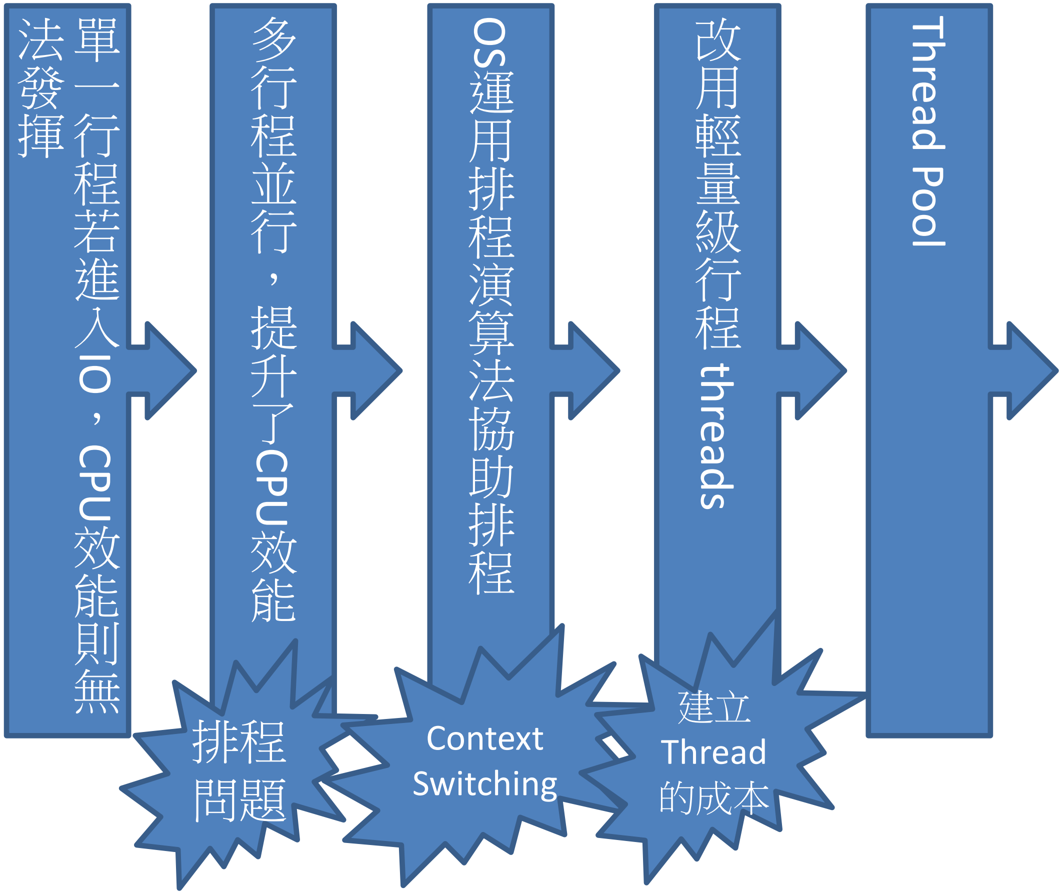
Semaphore

P_1	P_2
…	…
A	wait(s)
Signal(s)	B
…	…

Synchronization

- 著名的同步問題
  - Dining philosophers problem
  - Producer-consumer problem
  - Readers-writers problem
  - Sleeping barber problem
- 解法：
  - Semaphore
  - Monitor
  - Critical Region



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多行程並行，提升了CPU效能

OS運用排程演算法協助排程

改用輕量級行程 threads

Thread Pool

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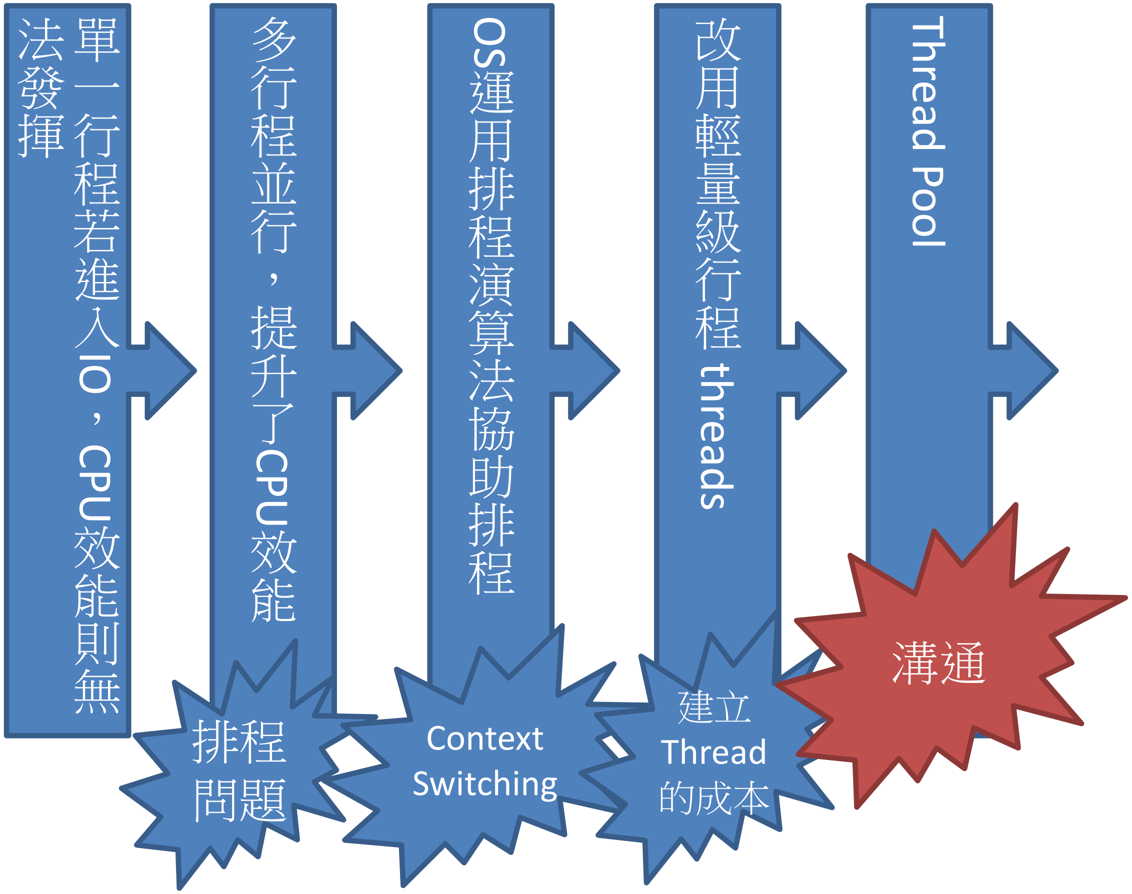
Context Switching

建立Thread的成本



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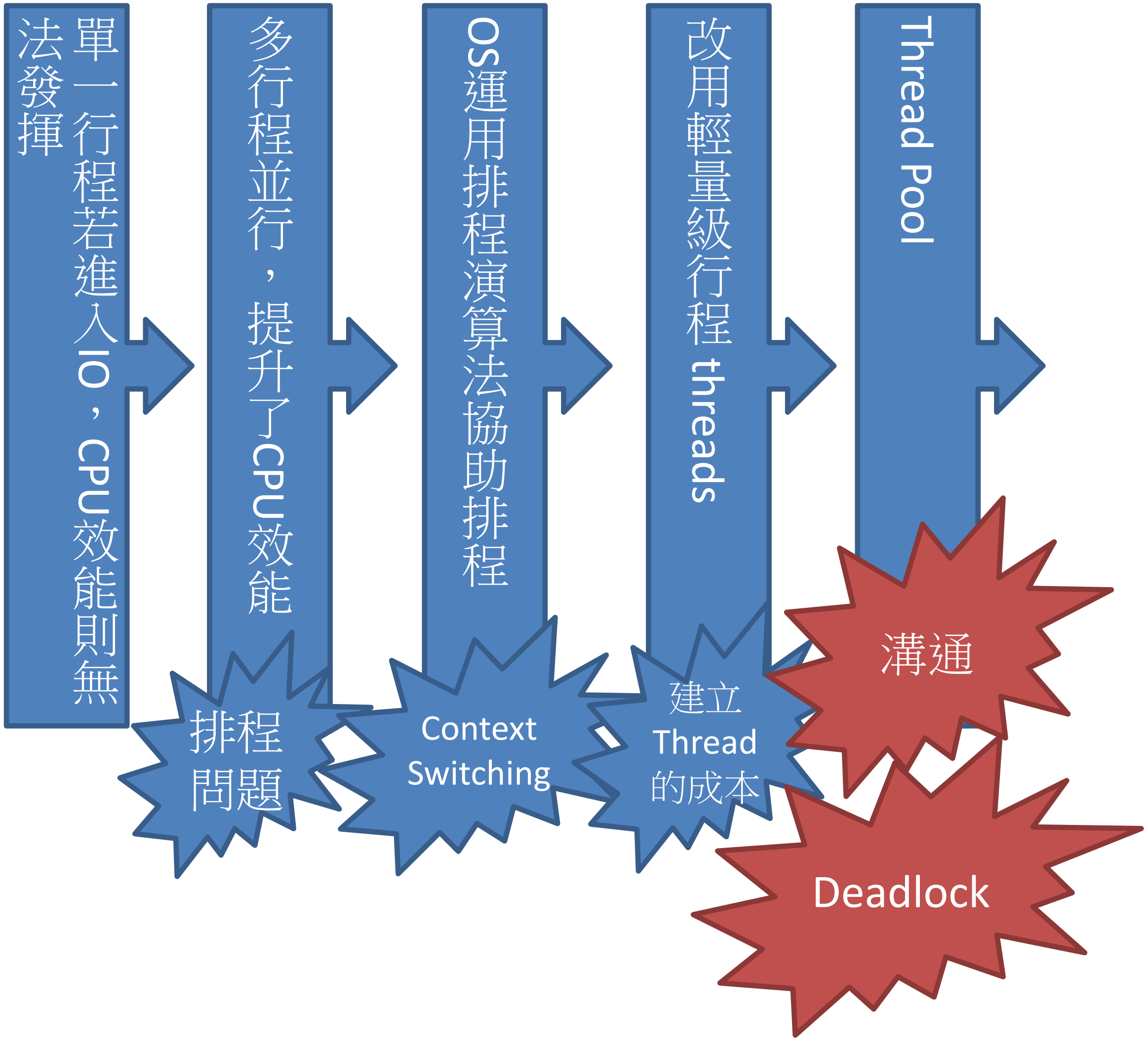

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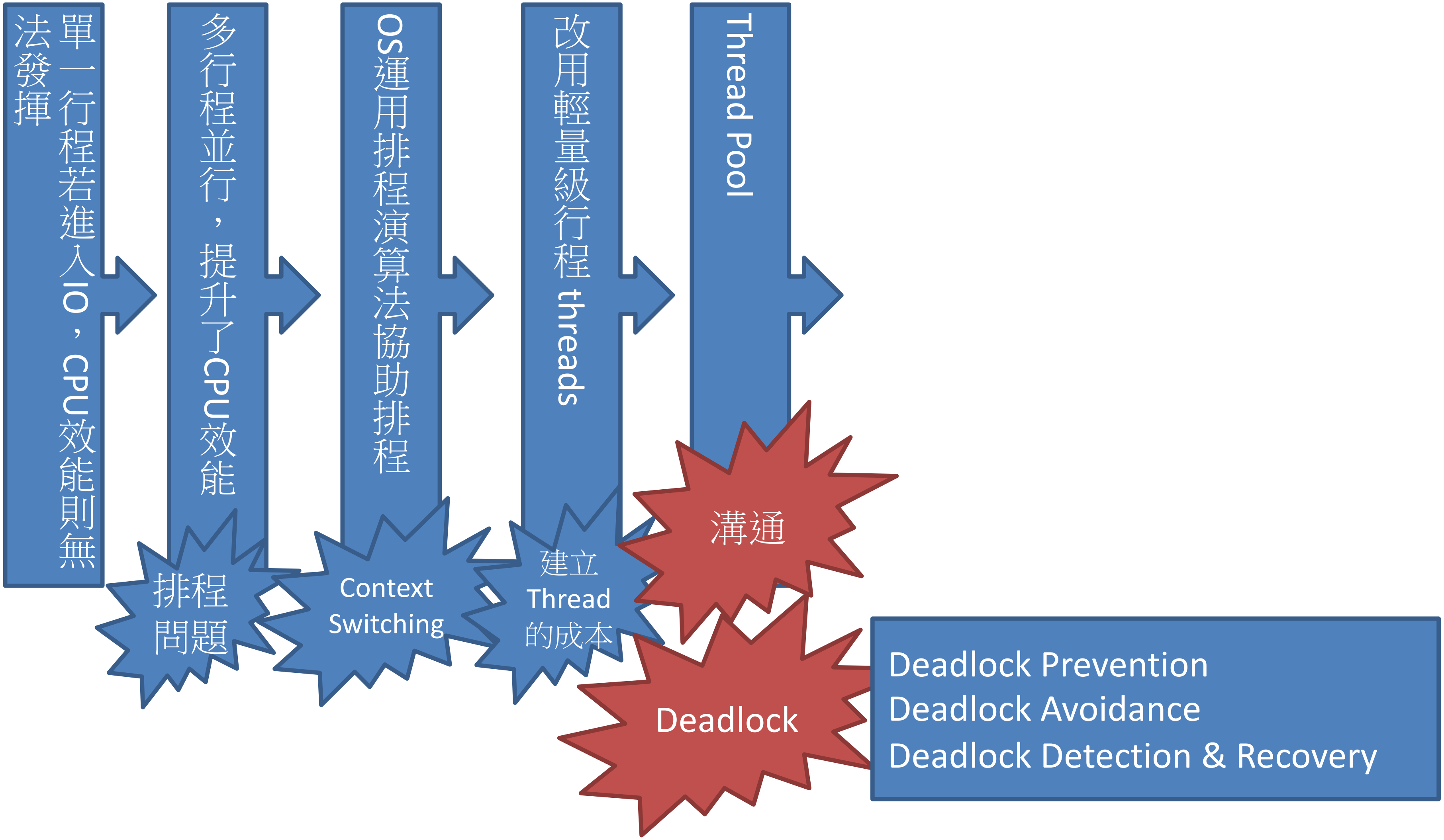

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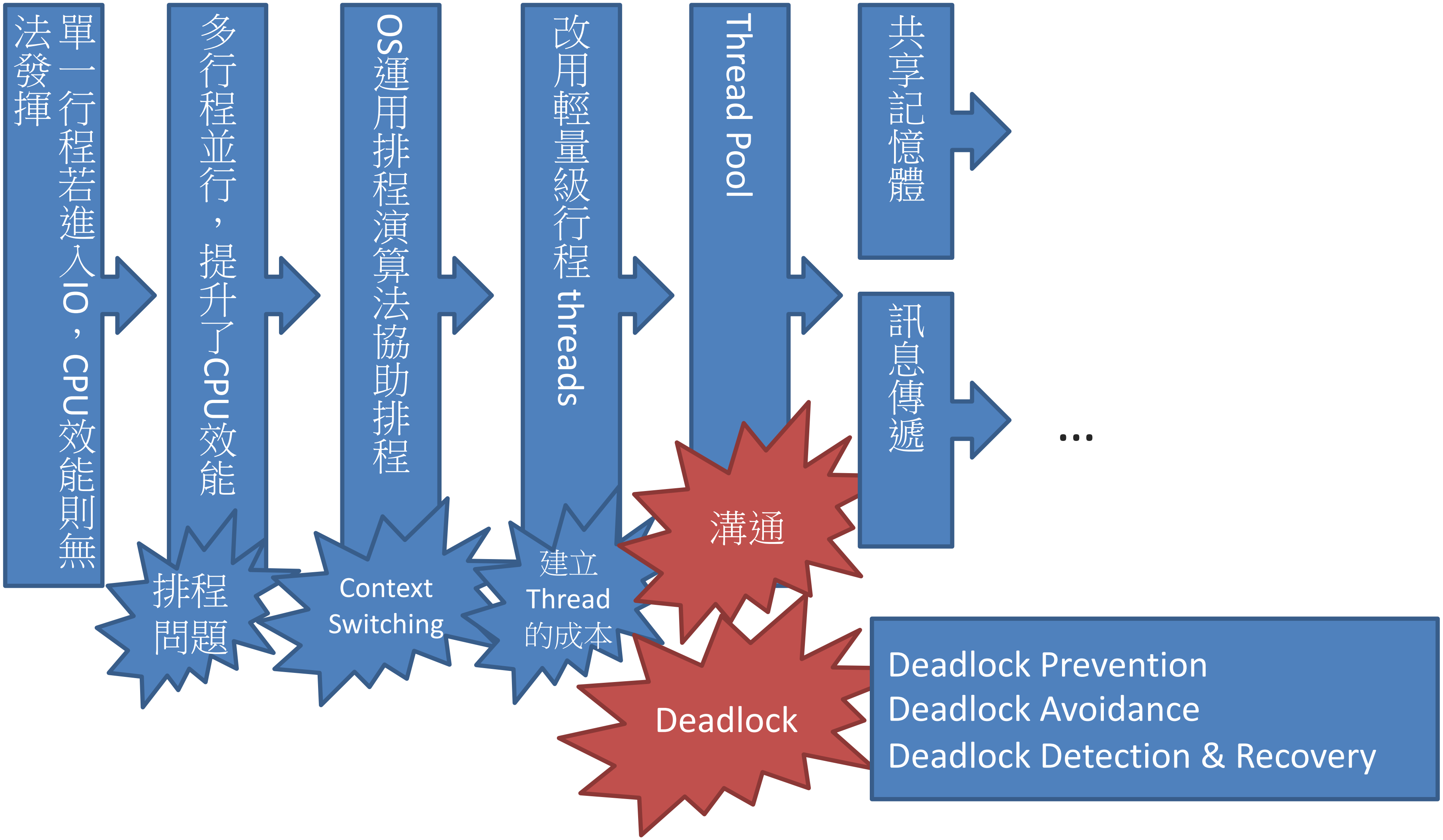
Deadlock Avoidance
Deadlock Detection & Recovery



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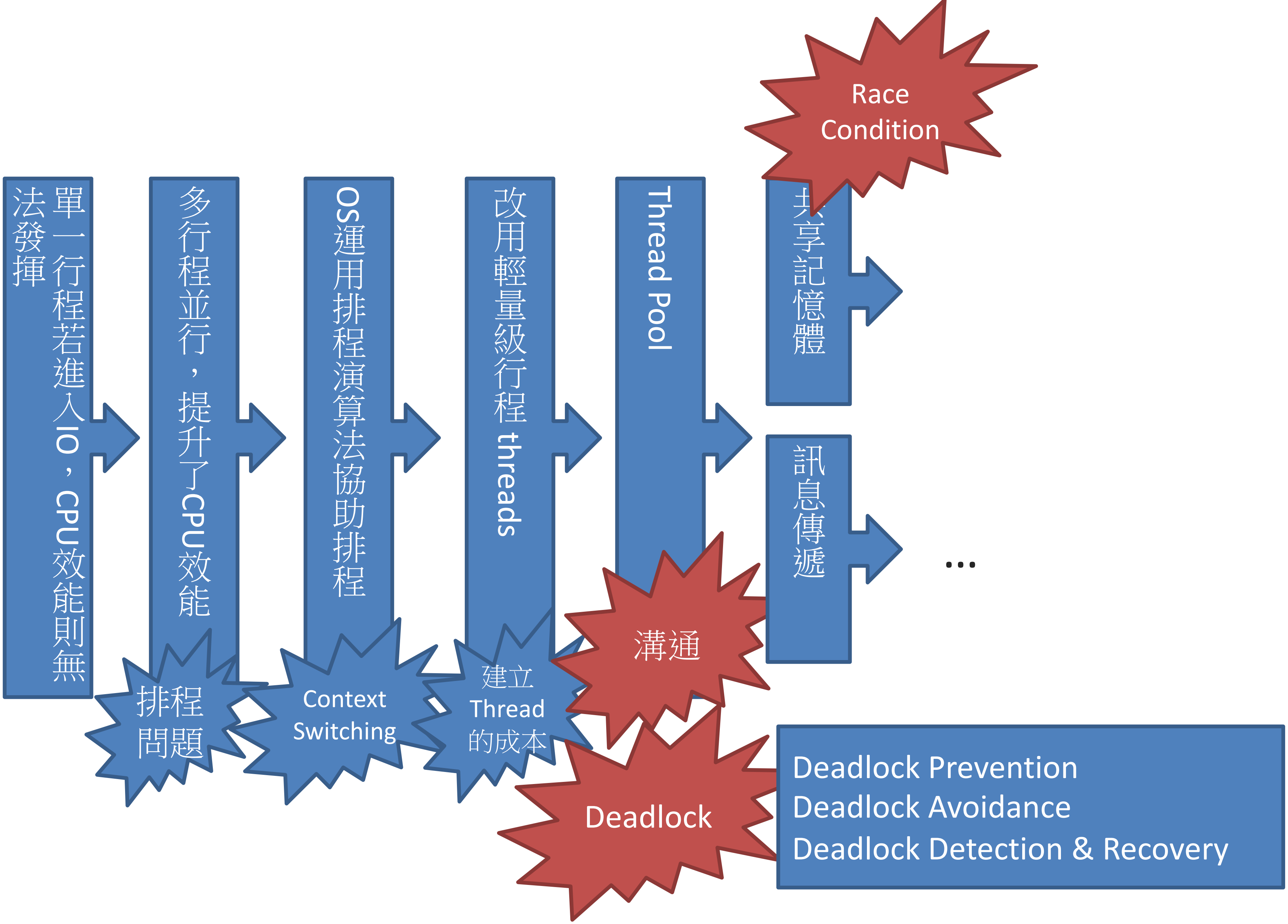

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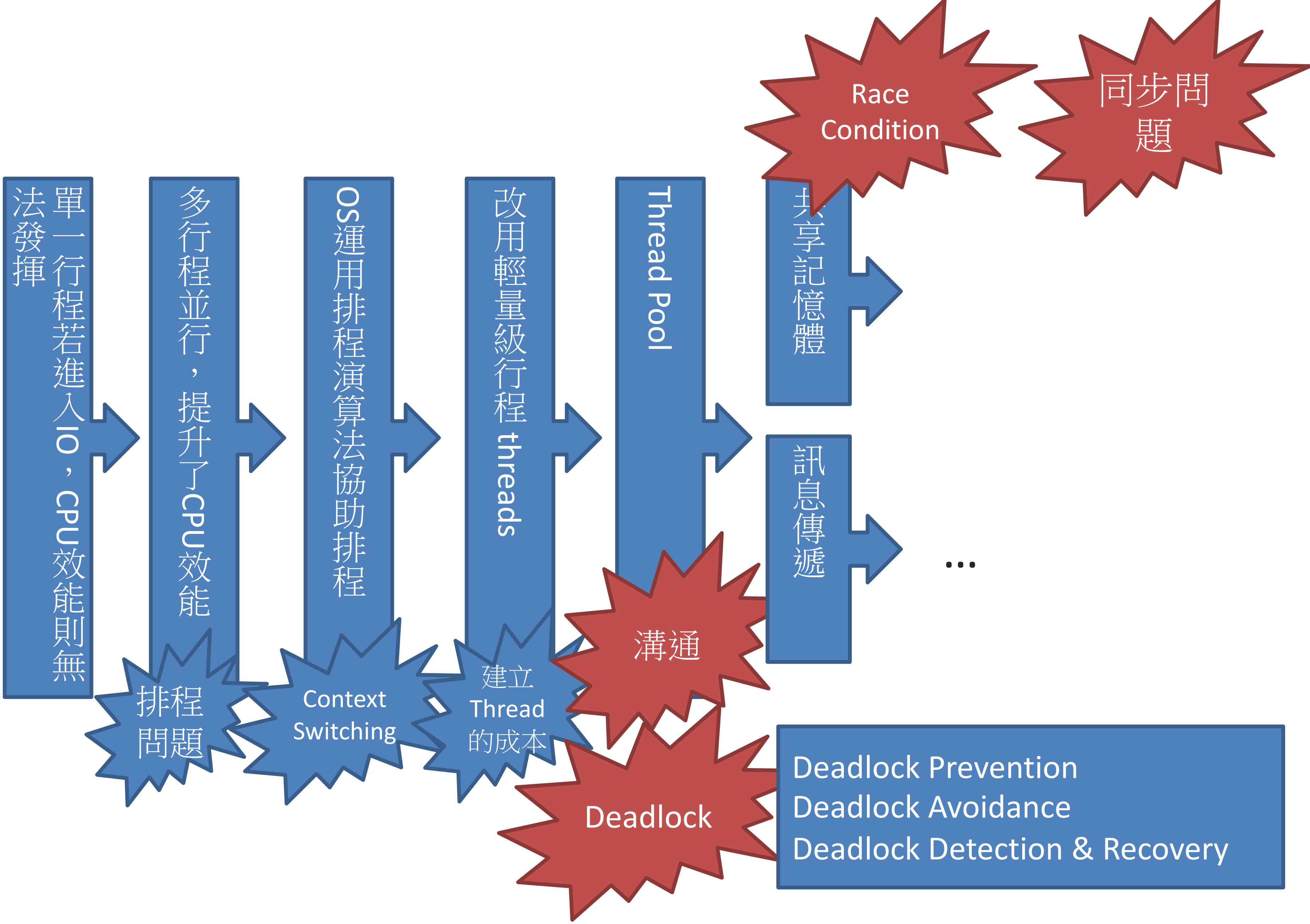

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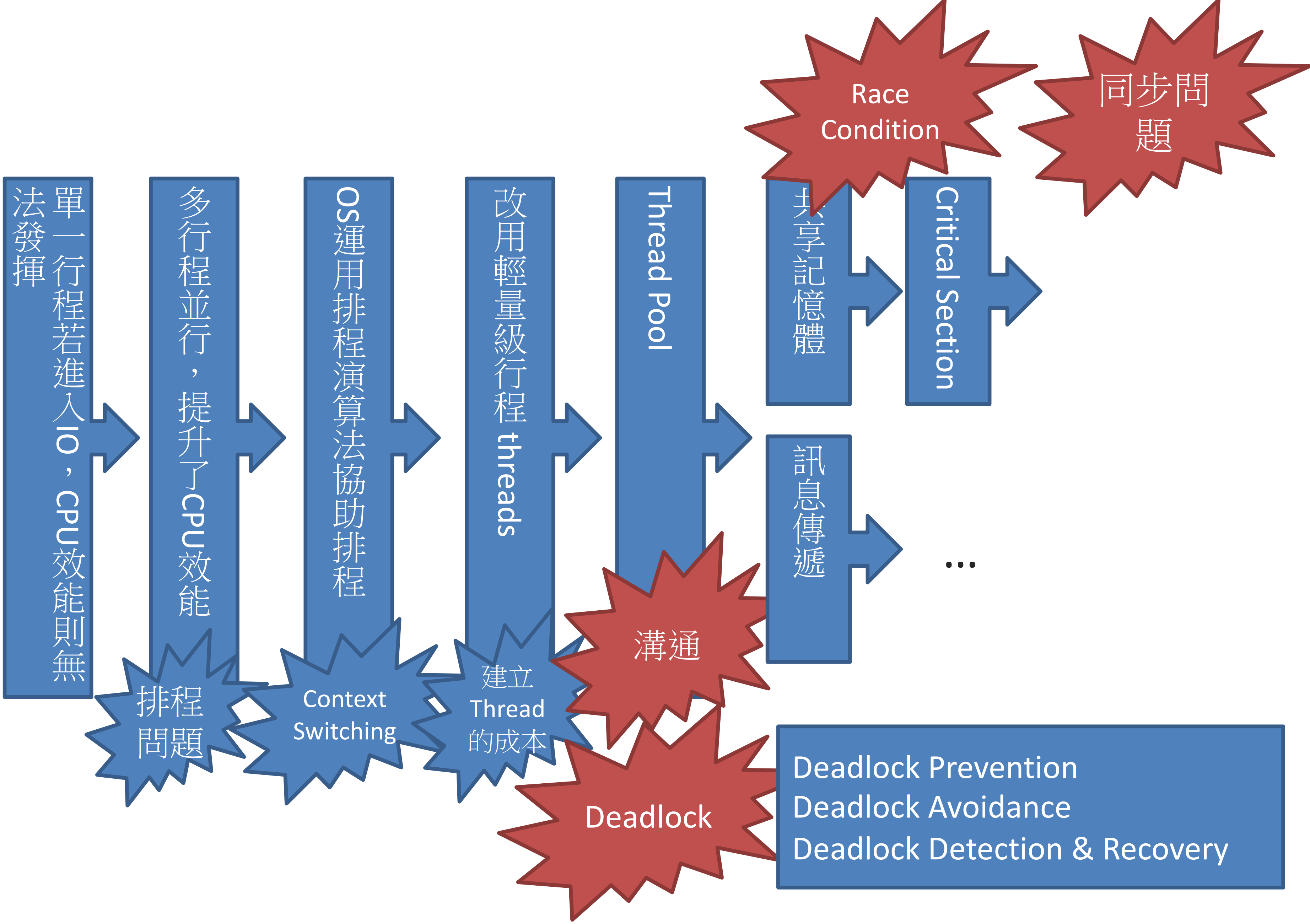

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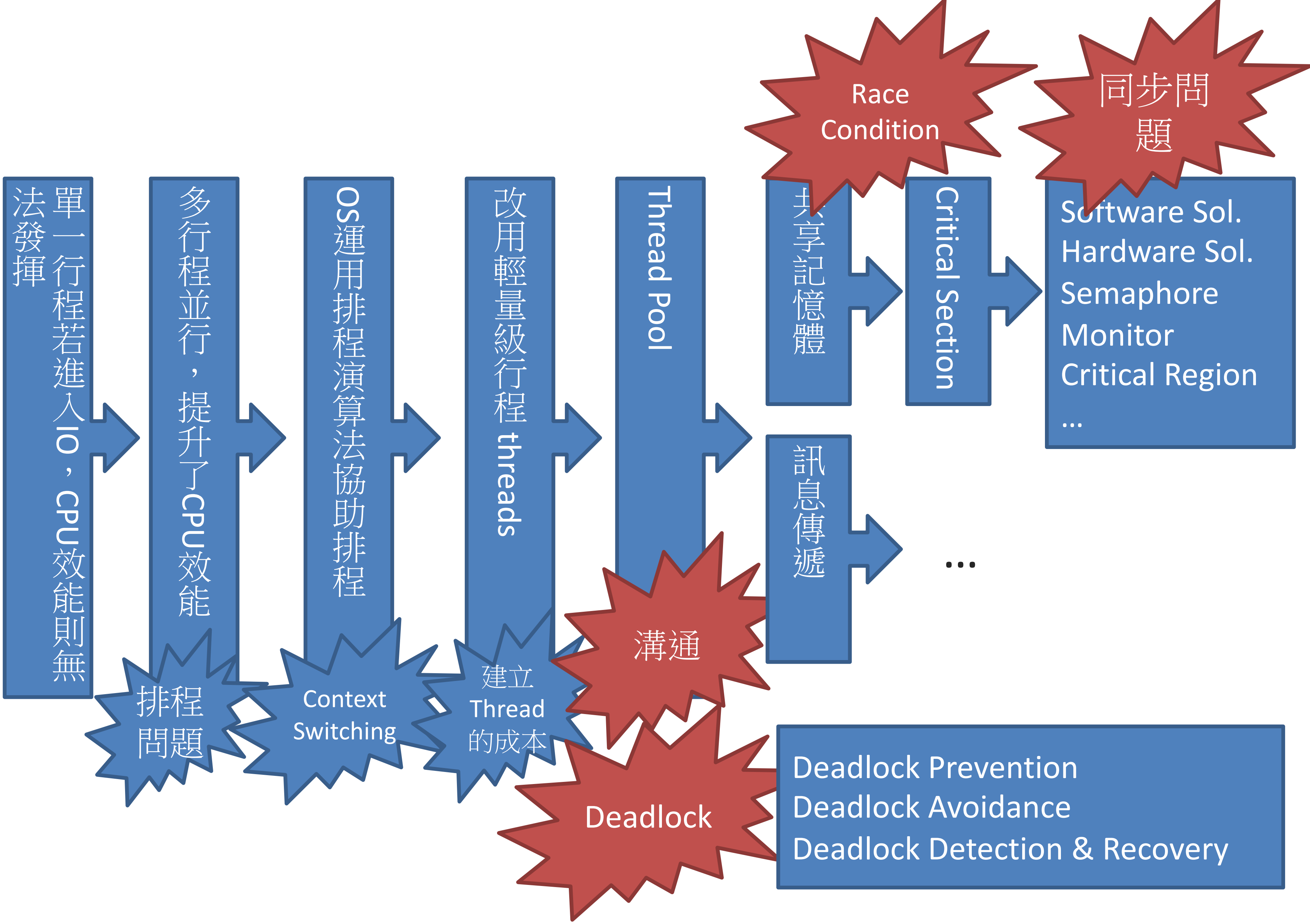

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Hardware Sol.
Semaphore
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…

訊息傳遞

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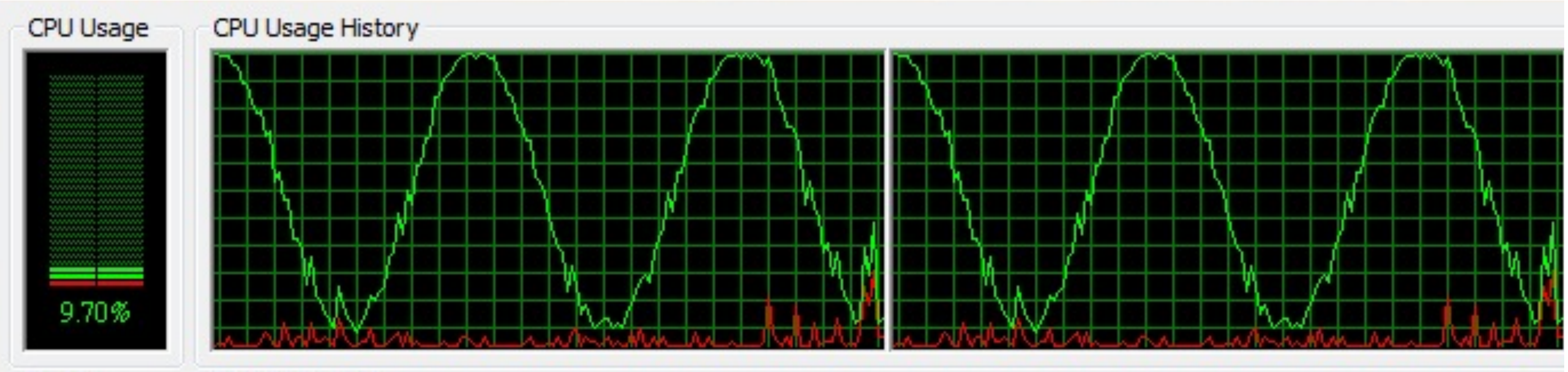
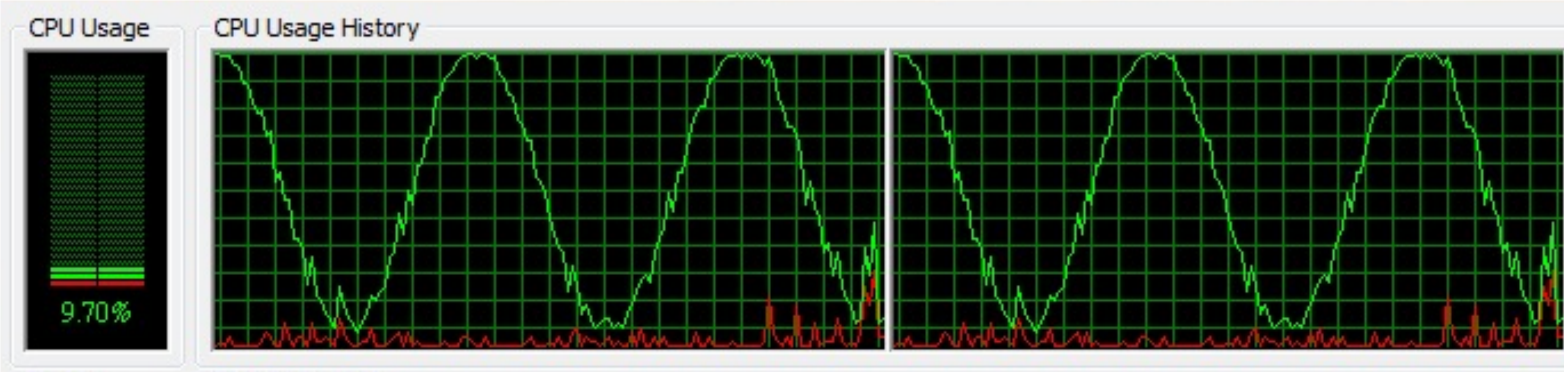
Deadlock

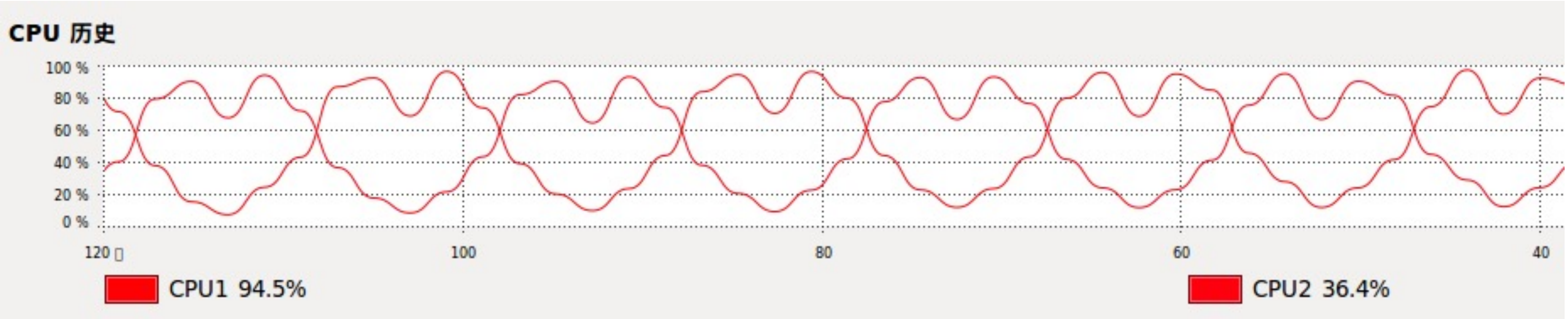
Deadlock Prevention
Deadlock Avoidance
Deadlock Detection & Recovery

補充



補充


CPU Usage
9.70%
CPU Usage History


CPU 历史
100 %
80 %
60 %
40 %
20 %
0 %
120
100
80
60
40
🟥 CPU1 94.5%
🟥 CPU2 36.4%