4. 一開始即用一個不錯的解可能會產生低成本最後解決，但未必都能夠得到最佳解。這也暗示使用 CRAFT 最好的策略是使用不同的起始點，以產生不同的交換方式。
5. 可處理部門達到 40 個，而取得答案所需重複的次數，大都不超過 10 次。
6. CRAFT 所規劃的部門皆由方塊模型組合（基本上每一方塊代表 10 呎*10 呎），這表示一個部門是由許多不同方格所組成，因此部門的形狀常常有奇怪的格局，故必須以手工加以修改，以達到實際可用的平面圖。
7. 一個修正過的模型如 SPACECRAFT 可以處理多樓層的平面圖。
8. CRAFT 假設現存的物料處理設備如堆高機的路徑是可變動。因此，當使用電腦化固定路徑之搬運設備，CRAFT 的應用性相對減低。

系統性佈置規畫

在一些特定佈置問題上，不是部門之間的物料流動的資料的獲得不切實際，就是對於配置決策不能反映非數量 (qualitative) 的因素。在這些情況下，可應用系統性佈置計畫 (Systematic Layout Planning, SLP) 可以應用，它使用一種關係圖來表示各個部門之間的重要性程度。從此張圖形發展出活動相關圖，此圖形類似物料流程圖。此活動相關圖經由反覆測試而達成一定的特定形態，此形態再依實際空間的限制及按部門順序加以修正。圖表 10.9 以百貨公司的 5 個部門在一個樓層的規畫，來描述此類的技術。

SLP 方法以數量方式來簡化評估各方案的佈置。依照其接近的程度而予以數值權數，然後測試不同的佈置安排。最後圈選的佈置是分數最高者。例如，Lofti 以及 Pegels 的教育軟體就是 A 代表 16 分，E 代表 8 分，I 代表 4 分，O 代表 2 分，U 代表 0 分以及以 X 代表-80 分，權數結構的選擇是任意的。但是以最不合理選擇(X=-80)比最合理選擇 (A 代表 16 分)相差 5 倍，是其基本邏輯。使用此軟體及此加權數計畫，圖表 10.9 的最後佈置之分數爲 40 分（此分數是以每兩個部門爲一對的權數加總分數，本案例爲 10 對部門，其中部門互換是採取隨機方式，依使用者的選擇，或由軟體任選）。

圖表 10.9 百貨公司同一樓層的系統性佈置規劃

A. 關係圖 (基於圖表 B 與 C)

從	到 2	3	4	5	面積 (平方呎)
1.信用部門	L 6	U -	A 4	U -	100
2.玩具部門		U -	Y 1	A 1,6	400
3.酒類部門			U -	X	300
4.照相部門				X	100
5.糖果部門			.		100

字母 接近度評比
數字 評比的理由

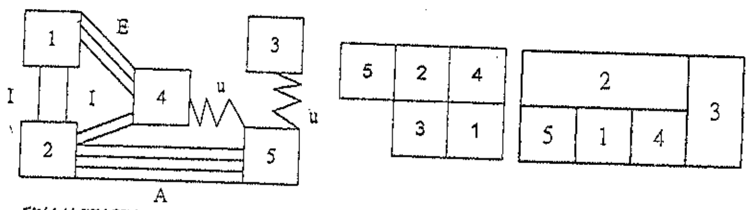
B.

代碼	理由*
1	顧客形態
2	監督容易性
3	一般人員
4	接觸的必要性
5	相同空間的分配
6	心理

*可以有其它理由

C.

價值	接近性	線代碼*	權數
A	絕對重要	≡≡	16
E	特別重要	≡	8
I	重要	=	4
O	普通接近	—	2
U	不重要		0
X	最好不要	/\/\	80



啓始的關係圖　啓始的佈置圖　最終的佈置圖

整合工廠佈置軟體與佈置計畫

「改善製造程序」的新趨勢方塊文章，說明目前工廠佈置計畫所使用很多新的軟體之一。此種方式異於 1980 年代，應用大型人工智慧系統來模式化規劃者對工廠佈置的偏好。

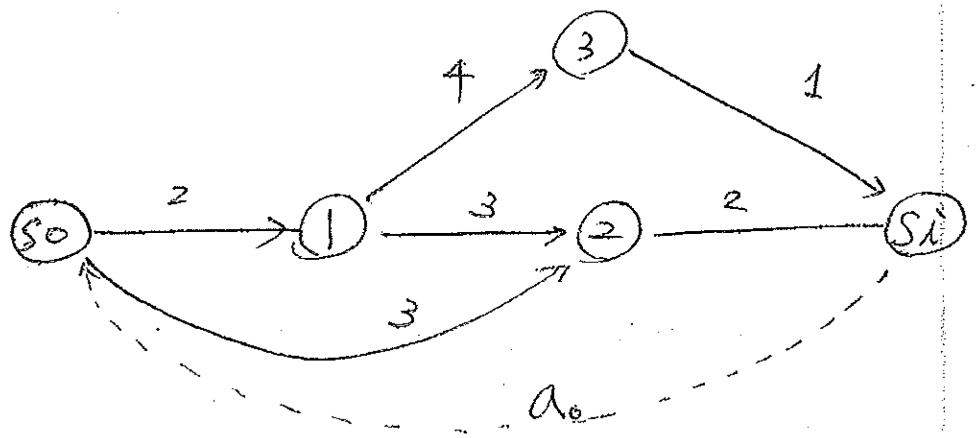
產品式佈置

產品式佈置 (Product Layout) 與功能式佈置兩者之間基本差異在於工作流程的形態。就像功能式佈置，流程形態有高度變動性。因爲在生產週期過程中，物料可能需多次經相同的加工部門。在產品佈置、設備或是部門都是專屬特定的產品線，重覆投資設備以避免物料

Maximum Flow Problems 最大流量(川流問題)

在許多情況下，網路之節線可視為有容量限制去建構模式。在這些情形下，通常想從一 starting point 起點(source 源點)運送最大之流量至一 terminal point 終點(sink 匯點)。這類之問題，諸如，自來水同一時間之最大流量，高速公路之路網最大流量等。

e.g.



Sunco Oil 公司想透過 pipeline 從 so 至 si 運送最大量的石油(在每小時)網路上之數字代表每小時可運過該節線之最大流量(每小時百万 barrels)由於管道的口徑大小不同。最大流量問題 p1

就是要決定，每小時從 S_0 至 S_i 最大流量。

令 X_{ij} 代表每小時會經过節点 (i, j)

百万 barrels.

X_0 : flow 經过 artificial arc, i.e. 進入 sink 的流量 (a_0)

$$\text{Max} \quad Z = X_0$$

s.t.

$$X_{s_0,1} \le 2$$
$$X_{s_0,2} \le 3$$
$$X_{1,2} \le 3$$
$$X_{2,s_i} \le 2$$
$$X_{1,3} \le 4$$
$$X_{3,s_i} \le 1$$

(Arc capacity constraints)

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conservation-of-flow constraint

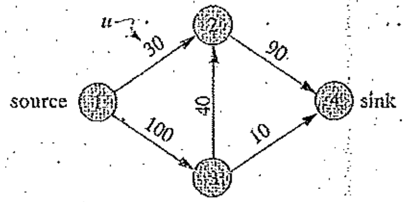
$$X_0 = X_{s_0,1} + X_{s_0,2}$$ (Node s_0 flow constraint)
$$X_{s_0,1} = X_{12} + X_{13}$$ (Node 1 flow constraint)
$$X_{s_0,2} + X_{12} = X_{2,s_i}$$ (Node 2 flow ")
$$X_{13} = X_{3,s_i}$$ (Node 3 flow ")
$$X_{3,s_i} + X_{2,s_i} = X_0$$ (Node s_i flow ")

$$X_{ij} \ge 0$$

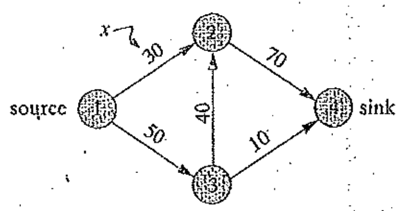
Optimal $Z = 3$, $X_{s_0,1} = 2$, $X_{s_0,2} = 1$, $X_0 = 3$.
$X_{1,3} = 1$, $X_{3,s_i} = 1$
$X_{1,2} = 1$, $X_{2,s_i} = 2$

SAMPLE EXERCISE 10.17: IDENTIFYING MAXIMUM FLOWS

Determine by inspection the maximum flow from node 1 to node 4 in the following graph (numbers on arcs are capacities $u_{i,j}$):



Analysis: Careful examination of the possibilities will establish that a maximum flow sends 80 units from 1 to 4 as follows:



EXAMPLE 10.4: BUILDING EVACUATION MAXIMUM FLOW

Maximum flow problems arise most often as subproblems in more complex operations research studies. However, they occur naturally in evaluating the safety of proposed building designs.[3] Proper design requires adequate capacity for building evacuation in the event of an emergency.

Figure 10.14 shows a small example involving a proposed sports arena. Patrons in the arena would exit in an emergency through doors on all four sides that can accommodate 600 persons per minute. Those doors lead into an outer hallway that can move 350 persons per minute in each direction. Egress from the hallway is through four firestairs with capacity 400 persons per minute and a tunnel to the parking lot accommodating 800 persons per minute. Our interest is in the maximum rate of evacuation possible with this design.

Part (b) of Figure 10.14 shows how we reduce this safety analysis to a maximum flow model. Patron flows originate at source node 1. Outbound arcs model the four doorways. The flows around the outer hall lead to the four stairways and the tunnel. Persons exiting by any of those means pass to sink node 10. Capacities enforce the flow rates of the various facilities.

We wish to know the maximum flow from 1 to 10, subject to the capacities indicated. An optimal flow is provided in the arc labels of part (b). Patrons can escape at a total rate of 2100 per minute.

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[3]Based in part on L. G. Chalmet, R. L. Frances, and P. B. Saunders (1982), "Network Models for Building Evacuation," *Management Science, 28*, 86–105. All numerical data and diagrams were made up by the author of this book.

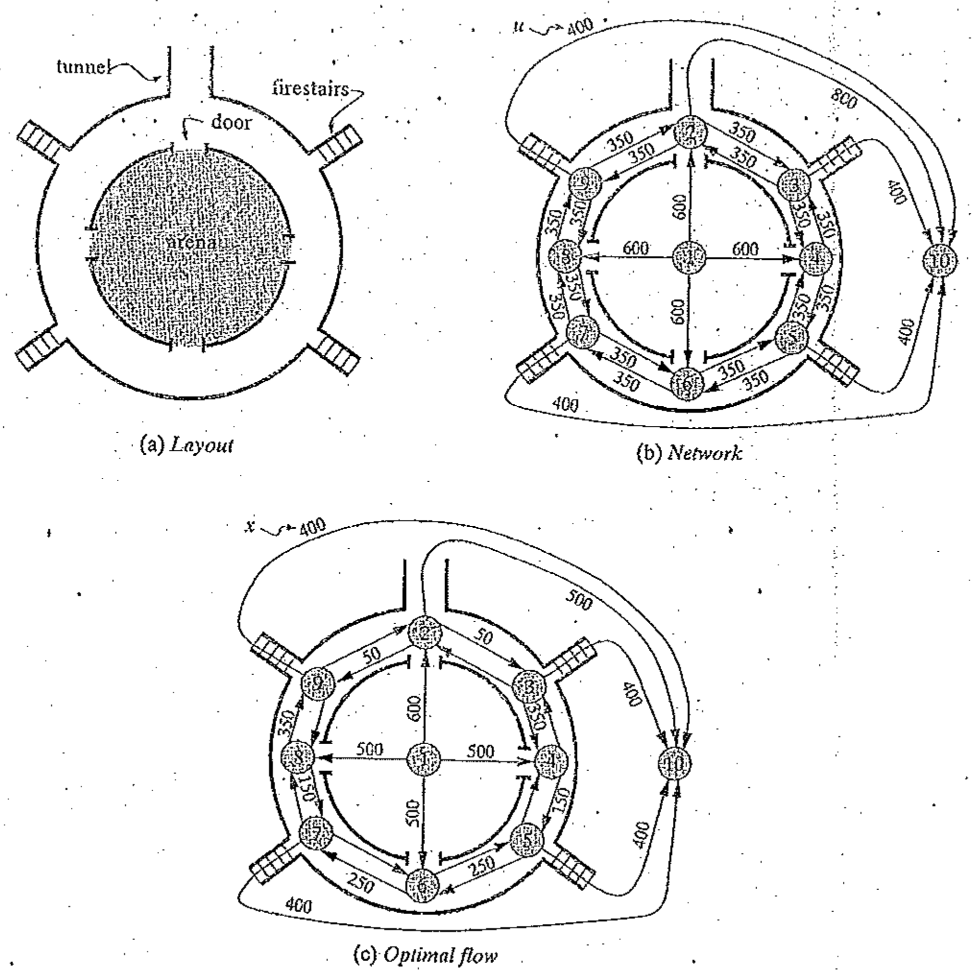


FIGURE 10.14 Building Evacuation Maximum Flow Example

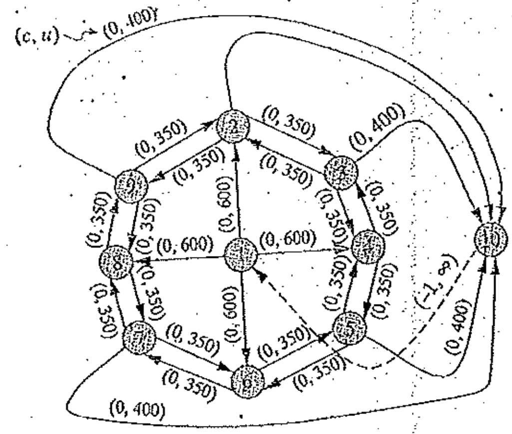
Return Arc Network Flow Formulation of Maximum Flow Problems

As so far presented, neither the tiny example of Sample Exercise 10.17 nor the larger one of Figure 10.14(b) is a minimum cost network flow problem. Flow conservation and capacity requirements are much like standard model 10.3, but we have specified no costs, and flows do not balance at source and sink.

To create a true minimum cost flow problem, we add a return arc.

10.31 **Return arcs** balance unknown source-to-sink flows by feeding back that flow in an artificial arc from sink to source.

Adding a return arc to the maximum flow example of Figure 10.14(b) produces the following digraph:



Artificial arc (10, 1) takes all flow reaching sink node 10 and returns it to source node 1, thus restoring flow balance (for net demand $b_k = 0$).

To finish a minimum cost network flow model, we need only introduce costs. Notice that the more the flow in return arc (10, 1), the greater the flow from source to sink. Thus we complete the model by placing a cost of -1 on flow in the return arc and taking all other costs as 0. Any minimum cost flow will necessarily maximize return arc, and thus source to sink flow.

10.32 Maximum flow problems can be modeled as minimum cost flows by adding a return arc from sink to source with cost -1. All net demands and all costs on other arcs are zero.

Although principle 10.32 assures that maximum flow problems can be solved by minimum cost network algorithms, even more efficient special-purpose procedures have been developed. See the references at the end of this chapter for details.

Sample Exercise 10.18: Modeling Maximum Flows as Networks

Develop a minimum cost network flow model corresponding to the maximum flow model of Sample Exercise 10.17.

***Modeling*:** Following construction 10.32, we add a return arc (4, 1) to obtain the following minimum cost flow problem: