

$$1. (1) \quad \frac{1}{10} = \frac{0.3}{10} + \frac{0.3}{30} + \frac{x}{20} + \frac{0.4-x}{1}$$

有部件3可改进比例:  $x = 0.357 = 35.79\%$ .

$$(2) \quad \text{比例为} \frac{\frac{0.2}{1}}{\frac{0.3}{10} + \frac{0.3}{30} + \frac{0.2}{20} + \frac{0.2}{1}} = 0.8$$

$\therefore$  比例为 80%.

$$\begin{aligned} 2. (1) \quad \text{CPI} &= \text{Base CPI} + \text{Extra Cost} \\ &= 1 + 20\% \cdot 4 + 80\% \cdot 10\% \cdot 8 \\ &= 2.440 \end{aligned}$$

$$\begin{aligned} (2) \quad \text{CPI} &= \text{Base CPI} + \text{Extra Cost} \\ &= 1 + 10\% \cdot 4 + 90\% \cdot 10\% \cdot 8 \\ &= 2.12 \end{aligned}$$

$$3. (1) \quad \text{平均访问时间} = \text{Hit Time} + \text{Miss Rate} \cdot \text{Extra Cost}.$$

$$\therefore \text{Access Time}_{\text{直接映像}} = 1 + 1.6\% \cdot 50 = 1.8t$$

$$\text{Access Time}_{2\text{-way}} = \cancel{1 + 1\% \cdot 50} \Rightarrow (1 + 10\%) (1 + 1\% \cdot 50) = 1.65t$$

(上式中  $t$  为直接映像 cache 中, 一个时钟周期的时间).

$$3.(2) \text{ CPU 时间} = IC \cdot (CPI \cdot \text{时钟周期长度} + \text{平均访存次数} \cdot \text{Miss Rate} \cdot \text{Miss Cost})$$

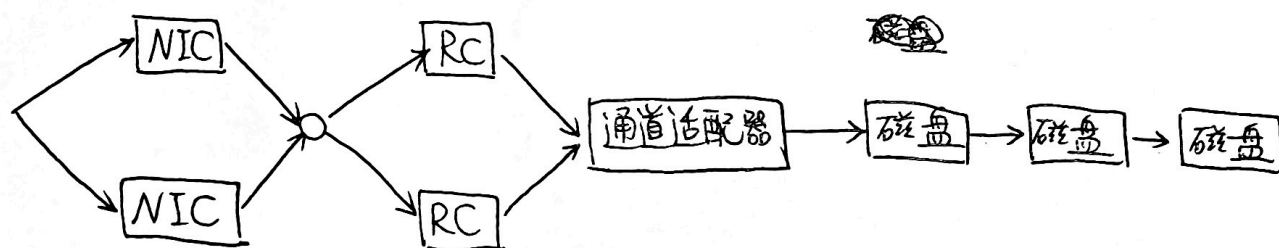
$$\therefore \text{CPUTime}_{\text{直接}} = IC \cdot (1t + 1.3 \cdot 1.6\% \cdot 50t) = 2.04t \cdot IC$$

$$\text{CPUTime}_{2\text{-way}} = IC \cdot (1.1t + 1.3 \cdot 1\% \cdot 50 \cdot (1.1t)) = 1.815t \cdot IC$$

$$\text{相对性能比, Rate} = \frac{\text{CPUTime}_{\text{直接}}}{\text{CPUTime}_{2\text{-way}}} = 1.124$$

综上所述, 两路组相连 CPU 性能强了 1.124 倍.

4. (1)



$$(2) R = (1 - (1 - R_1)^2) \cdot (1 - (1 - R_2)^2) \cdot R_3 \cdot R_4^3$$

$$(3) R = 0.63 = 62.83\%$$

$$5.(1) \text{ Cube2}(9) = 9 \text{ xor } \text{bin}(0100) = 13$$

$$\text{shuffle}(7) = \sigma(7) = 7 \ll 1 = 14$$

$$\beta(14) = 7$$

$$\text{Cube0}(\sigma(11)) = \text{Cube0}(7) = 6$$

$$\text{PM2I-2}(5) = (5 - 2^2) \bmod 16 = 1$$

(2) 10 的二进制为 1010, 6 的二进制为 0110.

$$1010 \rightarrow 1011 \rightarrow 0111 \rightarrow 0110$$

$\therefore$  至少经过 3 步. 依次经过  $10 \rightarrow 11 \rightarrow 7 \rightarrow 6$ .

6. (1) Forbidden List = {1, 3}

冲突向量为 101.

(2) 状态图为



显然, 最优调度方案为每 2 周期一个任务.

$$\text{吞吐率为 } \frac{5}{11\Delta t} = \frac{0.45}{\Delta t}.$$

$$\text{流水线利用率为 } \frac{5 \times 3}{11 \times 3} = \frac{5}{11} = 45.45\%.$$

7. 假设编译好的程序依次执行以下指令:

$$r_1 = A_1 \cdot B_1, \quad r_2 = A_2 \cdot B_2, \quad r_3 = A_3 \cdot B_3, \quad r_4 = A_4 \cdot B_4, \quad r_5 = A_5 \cdot B_5.$$

$$s_1 = r_1 + r_2, \quad s_2 = r_3 + r_4, \quad s_3 = r_5 + s_1, \quad \text{sum} = s_2 + s_3.$$

∴ 时空图为

	$r_1$	$r_2$	$r_3$	$r_4$	$r_5$	$s_1$	$s_2$	$s_3$			$s$	
						$s_1$	$s_2$	$s_3$			$s$	
					$s_1$	$s_2$	$s_3$			$s$	$s$	
	$r_1$	$r_2$	$r_3$	$r_4$	$r_5$							
	$r_1$	$r_2$	$r_3$	$r_4$	$r_5$	$s_1$	$s_2$			$s$		

20个时钟周期内, 输出了9个结果. 吞吐率为  $TP = \frac{9}{20\Delta t}$ .

如果不用流水线, 每次加法用  $5\Delta t$ , 乘法用  $3\Delta t$ , 故有加速比:

$$S = \frac{4 \cdot 5\Delta t + 5 \cdot 3\Delta t}{20\Delta t} = 1.75$$

流水线的效率为面积的比值:  $E = \frac{20+15}{20 \cdot 5} = 0.35 = 35\%$

(注: 经测试, 将  $r_5$  与  $s_1$  计算顺序调换, 仍为 20 个时钟周期, 所有答案不变).