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$$5. CP_{J,(2)} = 85\% \times 1 + 15\% \times 3 \\ = 1.3$$

$$CP_{J,(A)} = 85\% \times 1 + 15\% \times (13\% \times 4 + 95\% \times 10\% \times 5 + 95\% \times 95\% \times 1) \\ = 1.599$$

$$S = \frac{1.3}{1.599} = 1.183$$

12. (1) $a_0 = 0;$

$$a_1 = 10000;$$

$$a_1 = a_0 + 0;$$

while(1)

$$\left\{ \begin{array}{l} a_3 = a_0 + 2; \\ a_2 = a_1 \% a_3 \end{array} \right.$$

if ($a_2 == a_0$)
 $\left\{ \begin{array}{l} \text{#...Code A} \\ \dots \end{array} \right.$

$$a_3 = a_0 + 5;$$

$$a_2 = a_1 \% a_3$$

if ($a_2 == a_0$)
 $\left\{ \begin{array}{l} \text{#...Code B} \\ \dots \end{array} \right.$

$$a_1++;$$

if ($a_1 == a_4$)

break;

 $\left\} \quad \right.$
12) $a_1: 0 \rightarrow 9999 \rightarrow 10000$ B1: $a_1 \% 2 \neq 0$ 跳转B2: $a_1 \% 5 \neq 0$ 跳转B3: $a_1 \neq 10000$ 跳转

10000次循环执行。B1不执行 5000次，④

B2不执行 2000次

B3 都次跳转。

最后一次 $a_1 = 10000$ 时不跳转。

$$\left\{ \begin{array}{l} B1: \frac{1}{5} \\ B2: \frac{4}{5} \\ B3: \frac{9999}{10000} \end{array} \right.$$

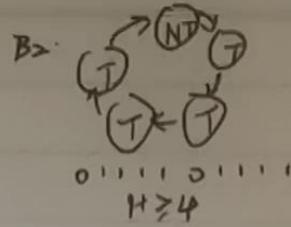
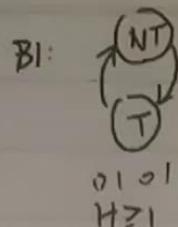
13) B1: 50%

B2: 80%

B3: 0.01%

$13.11 \cdot 2^k \geq 3$
 $k \geq 2$,
 (1) $B_1: NT\ T\ NT\ T\ \dots$
 $B_2: NT\ T\ T\ T\ T\ NT\ T\ T\ T\ T\ NT\ \dots$
 $B_3: \underbrace{T\ T\ \dots}_{9999\text{次}} \underbrace{T\ NT}$
 N-bit 计数器初值为 0, 2^{N-1} 次跳转后预判跳转
 ① 对于 B_1 : $NT\ T\ NT\ T\ NT\ \dots$
 1-bit 预判 $0\ 0\ 1\ 0\ 1\ \dots$ 正解 $\frac{1}{10000}$
 2-bit $00\ 00\ 01\ 00\ 01\ \dots$ 正解 $\frac{1}{2}$
 $N \geq 2$ 时, 均为 $\frac{1}{2}$. B_1 而言, $N \geq 2$ 时, 正解。
 ② $B_3: T\ T\ \dots\ T\ NT$
 $N=1: 0\ 1\ \dots\ 1\ 1$ 正解 $1 - \frac{2}{10000}$
 $N=2: 00\ 01\ 10\ 11\ \dots\ 10$ 正解 $1 - \frac{3}{10000}$
 N -bit, 正解 $1 - \frac{1+2^{N-1}}{10000}$, $N \leq 4$, $N \geq 15$ 时, $2^{N-1} > 10000$ 正解为 0.
 $\therefore B_3 \text{ 和 } B_3: 1 \leq N \leq 14$
 ③ $B_2: NT\ T\ T\ T\ T\ NT\ T\ T\ T\ NT\ T\ T\ T\ T\ T\ T\ T\ T$
 $N=1: 0\ 0\ 1\ 1\ 1\ 1\ 0\ 1\ 1\ 1\ 1\ 0\ 1\ 1\ 1$ 正解 $1 - \frac{\frac{10000}{3}}{10000} = \frac{2}{3}$
 $N=2: 00\ 01\ 01\ 10\ 11\ 11\ 10\ 11\ 11\ 11\ 11\ 10\ 11\ 11\ 11$ 正解 $1 - \frac{\frac{10000}{5}}{10000} = \frac{4}{5}$
 $\therefore N \geq 2$
 (3) $N=2$ 时, $B_1: \frac{1}{2}$, $B_2: 79.99\% \approx 80\%$, $B_3: 1 - \frac{3}{10000} = 99.97\%$

14.



B3: T (稳态时)
H 伍

$\therefore H \geq 4$

15. B1 NT T NTT NT T NTT NT T

表3: B2 NT T T T T NT T T T T ...

B3 T T T T T T T T T T T T T T

00|11|01|11|01|101|01|11|01|11|02|11|
1位 X 7位 (110111) X |

2位 X 01歧义 8位 (1110111) X

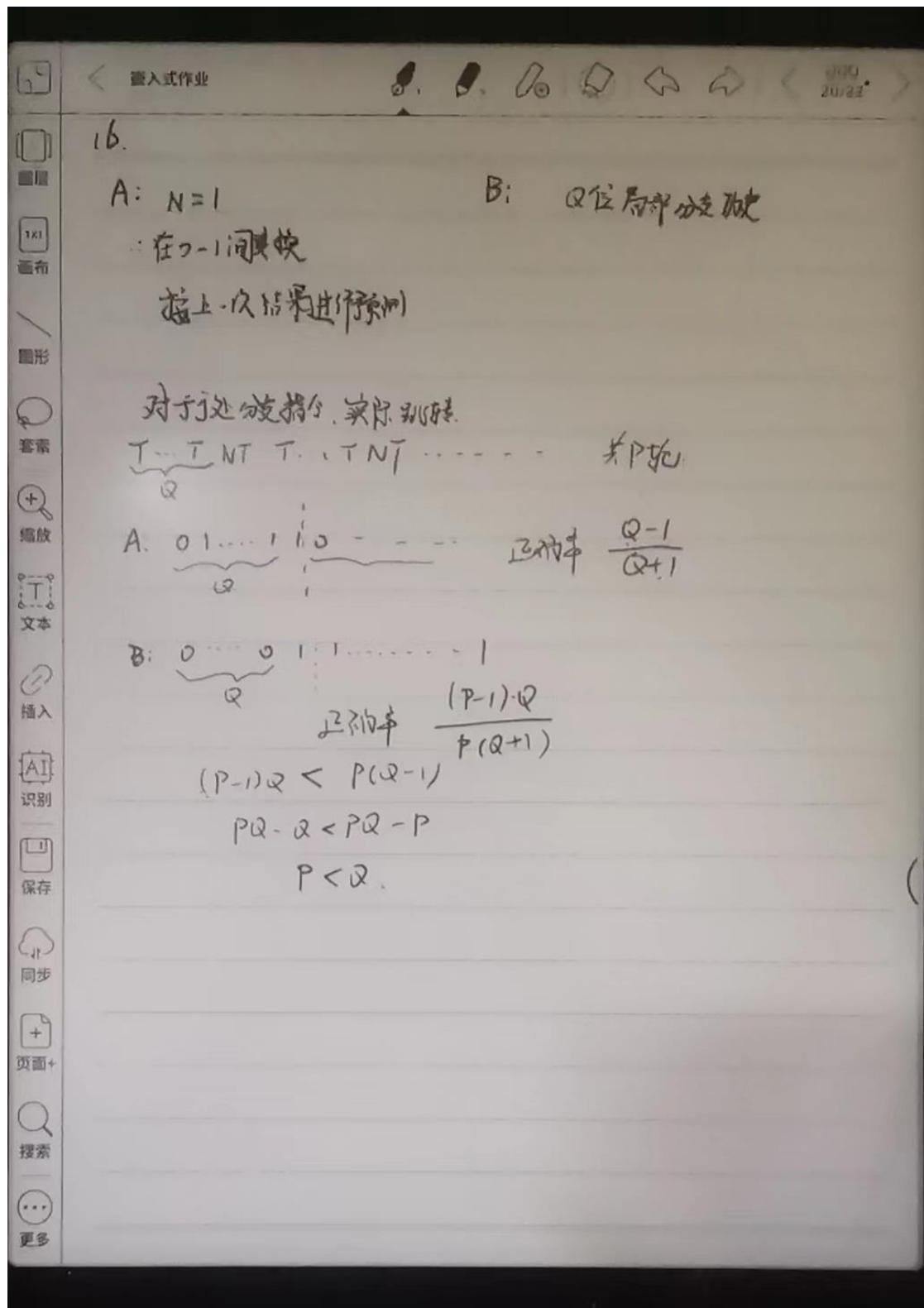
3位 X 111歧义 9位 (110111110) X

4位 X 0111歧义 10位 (0111110111) X

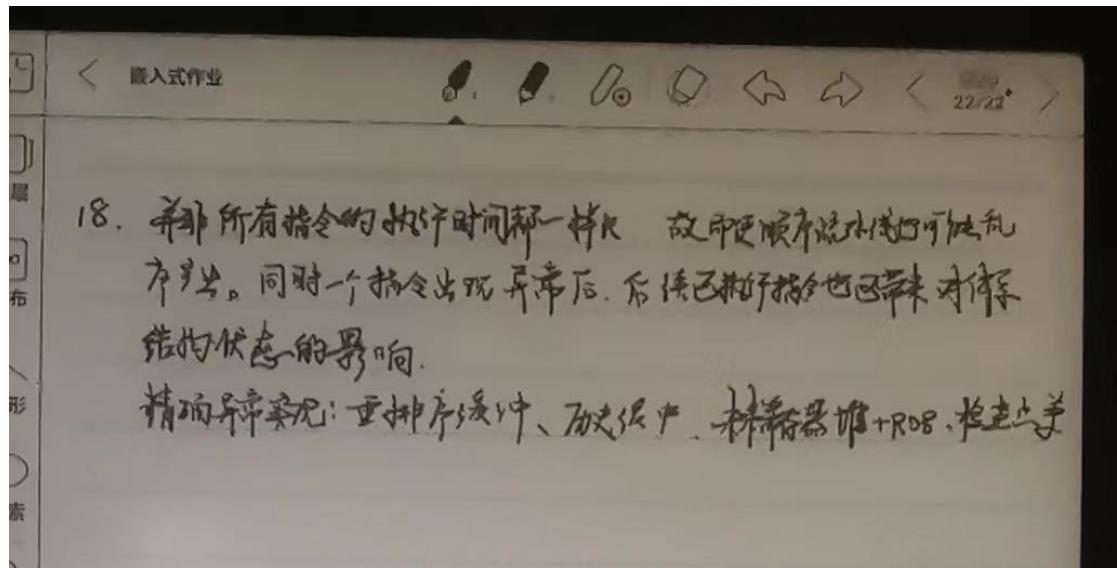
5位 X 01111歧义 11位 ✓

6位 X 110111歧义

∴ 至少11位 保证分支表中同一行 对应计数器只有1值



17. $a_1 \cdot n$ do
 $a_2 \cdot o$ $\left\{ \begin{array}{l} a_4 = a_3 [e] \\ a_2 = 1; \\ a_1 = 1, \end{array} \right.$
 $a_3 \cdot p.$
 B2: $\underbrace{T \dots T}_{n-1} NT$ if $(a_4 = e)$ continue,
 B1: $\underbrace{NT T NT \dots}_n$ $a_2 \neq 1;$
 $\left\{ \begin{array}{l} a_4 = 1 (a_1 = 2), \\ a_3 = 1 (a_1 = 1), \end{array} \right.$
 (1) 2次, $n=6$
 B2: $T T T T T T NT$
 $00 01 11 11 11 11 11$
 $X X X X$
 B1: $NT T NT T NT T NT T$
 $00 00 01 00 01 00 01 00 01 00 01 00 01$
 $X X X X X X$
 共7次.
 (2) B1: $NT T NT T NT T NT T$
 B2: $T T T T T T T T NT$
 $00 11 10 11 10 11 10 11 10 11 10 11$
 $X X X X X X X X X X$
 共8次.
 (3) $00 00 01 11 11 10 01 11 11 10 01 11 11 10 01 11$
 $00 00 00 10 10 11 01 01 11 01 11 01 11 01 11 0$
 共9次.
 (4) n 足够大时 2位局部强弱模式 (5) 2位全局强弱模式
 强化



如果 ROB 的深度是无限的，将下表补充完全。（部分结果已给出）

	周期			操作码	目标	源 1	源 2
	Decode (ROB enqueue)	Issue	WB				
I1 [□]	0 [□]	1 [□]	2 [□]	3 [□]	fld [□]	T0 [□]	a0 [□] — [□]
I2 [□]	1 [□]	3 [□]	13 [□]	14 [□]	fmul.d [□]	T1 [□]	T0 [□] f0 [□]
I3 [□]	2 [□]	14 [□]	16 [□]	17 [□]	fadd.d [□]	T2 [□]	T1 [□] f0 [□]
I4 [□]	3 [□]	4 [□]	5 [□]	18 [□]	addi [□]	T3 [□]	a0 [□] — [□]
I5 [□]	4 [□]	5 [□]	6 [□]	19 [□]	fld [□]	T4 [□]	T3 [□] — [□]
I6 [□]	5 [□]	13 [□]	23 [□]	24 [□]	fmul.d [□]	T5 [□]	T4 [□] T4 [□]
I7 [□]	6 [□]	24 [□]	26 [□]	27 [□]	fadd.d [□]	T6 [□]	T5 [□] T2 [□]

如果 ROB 仅容纳 2 条指令，当一条指令提交后的下一周期该条目可以被新指令占据。重新将下表补充完全。（部分结果已给出）

	周期			操作码	目标	源 1	源 2
	Decode (ROB enqueue)	Issue	WB				
I1 [□]	0 [□]	1 [□]	2 [□]	3 [□]	fld [□]	T0 [□]	a0 [□] — [□]
I2 [□]	1 [□]	3 [□]	13 [□]	14 [□]	fmul.d [□]	T1 [□]	T0 [□] f0 [□]
I3 [□]	4 [□]	14 [□]	16 [□]	17 [□]	fadd.d [□]	T2 [□]	T1 [□] f0 [□]
I4 [□]	15 [□]	16 [□]	17 [□]	18 [□]	addi [□]	T3 [□]	a0 [□] — [□]
I5 [□]	18 [□]	19 [□]	20 [□]	21 [□]	fld [□]	T4 [□]	T3 [□] — [□]
I6 [□]	19 [□]	21 [□]	31 [□]	32 [□]	fmul.d [□]	T5 [□]	T4 [□] T4 [□]
I7 [□]	22 [□]	32 [□]	34 [□]	35 [□]	fadd.d [□]	T6 [□]	T5 [□] T2 [□]