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COA

- Internal Bus => ib
- a, b, c, ... are general registers
- ALU - Arithmatic Logical Unit - performs arithmatic op.
  - uses special registers - "s" and "t"

1) How a=4 will be executed.

```
ib <- 4
a <- ib
```

2) How a = a+1 will be executed

```
ib <- a
s <- ib
ib <- 1
t <- ib
ib <- s+t
a <- ib
```

3) Printing the value of a :

```
ib <- a
print(ib)
```

* PC: Program counter - stores the line number which has to be executed next.

Hence PC is incremented regularly

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* When 0th instruction is executed, it got incremented to 1 in background automatically

4) a = 4
do {
a = a + 1;
print(a);
} while(1);

Print 5, 6, 7, 8, ...

Architecture program

0: ib ← 4
1: a ← ib
2: ib ← a
3: s ← ib
4: ib ← 1
5: t ← ib
6: ib ← s + t
7: a ← ib
8: ib ← a
9: Print(ib)
10: ib ← 2
11: PC ← ib
↳ Program Counter

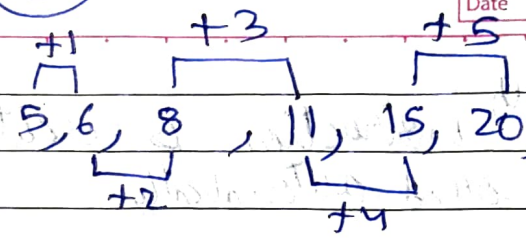
Efficient Version -

0: ib ← 4
1: s ← ib
2: ib ← 1
3: t ← ib
4: ib ← s + t
5: Print(ib)
6: s ← ib
7: ib ← 4
8: PC ← ib

a, b, C ≡ general registers
s, t ≡ arithmetic registers
↳ only s, t can be used for ALU operations

From s and t, value cannot be read, can only be written.
Hence ib ← s (Not allowed)
s ← ib (allowed)
ib ← s + t (allowed)

3



- Program to print 5, 6, 8, 11, 15, 20, ...

```
a = 5
b = 0
do{
    a = a+b
    Print(a)
    b = b+1
} while(1)
```

- Code using only 3 counters - a, s and t.

```
0: ib ← -5
1: a ← -ib
2: ib ← -0
3: t ← -ib
4: ib ← -a
5: s ← -ib
6: ib ← -s+t
7: a ← -ib
8: Print(ib)
9: ib ← -1
10: s ← -ib
11: ib ← -s+t
12: t ← -ib
13: ib ← -4
14: PC ← -ib
```

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→ AND and OR gate-

symbol

AND - (.)

OR - (+)

→ Boolean inequalities - a, b, c, d ≡ boolean variables

→ normal addition

i) $5a+7b >= 3 \Rightarrow a=1 \text{ or } b=1 \Rightarrow a+b$ Ans

ii) $8a+3b >= 10 \Rightarrow a=1 \text{ and } b=1 \Rightarrow a.b$

iii) $3a+7b+2c >= 8 \Rightarrow b=1 \text{ and } (a \text{ or } c)=1 \Rightarrow b.(a+c)$

iv) $7a+4b+3c >= 6 \Rightarrow a=1 \text{ or } (b=1 \text{ and } c=1)$
$\Rightarrow a+b.c$

v) $7a+4b+3c+20d >= 26 \Rightarrow d=1 \text{ and } (a=1 \text{ or } (b=1 \text{ and } c=1))$
$\Rightarrow d.(a+b.c)$

vi) $3a+7b+2c+20d >= 8 \Rightarrow d=1 \text{ or } (b=1 \text{ and } (a=1 \text{ or } c=1))$
$\Rightarrow d+(b.(a+c))$

vii) $7a+4b+3c+20d+22e >= 26$

$\Rightarrow e=1 \text{ and } (d=1 \text{ or } a=1 \text{ or } (b=1 \text{ and } c=1))$

OR

$e=0 \text{ and } (d=1 \text{ and } (a=1 \text{ or } (b=1 \text{ and } c=1)))$

$\Rightarrow e.(d+a+b.c)+d.(a+bc)$

$\Rightarrow ed+(e+d).(a+bc)$

viii) $5a - 7b >= -4$ ⇒ Everything other than $a=0$ and $b=1$

⇒ $(a'.b)'$ ⇒ $a + b'$

ix) $7a + 4b - 3c + 20d >= 23$

If $c=0$ ⇒ $7a+4b+20d >= 23$ ⇒ $d.(a+b)$ ∴ ⇒ $c'.d.(a+b)$

If $c=1$ ⇒ $7a+4b+20d >= 26$ ⇒ $a.d$ (No role of b here)

∴ Net Answer ⇒ $c'd.(a+b) + c.a.d$

⇒ $d.(c'(a+b) + (a)$

⇒ $d.(a + c'b)$

1— Write inequality for the sol^n $a + b'.c$

⇒ True when $a=1$ or $(b=0$ and $c=1)$

$10a - 4b + 6c >= 5$

2— . . . . . $a.b + c.d$

$a + b + c + d >=$

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$a.b + c.d$

$pa + qb + rc + sd \geq x$

— $p + q \geq x$ (1)

$r + s \geq x$ (2)

$p + r < x$ (3) $p + s < x$ (5)

$q + s < x$ (4) $q + r < x$ (6)

$p < x$

$q < x$

$r < x$

$s < x$

Adding (1) and (2),

$p + q + r + s \geq 2x$

Adding (3) and (4)

$p + q + r + s < 2x$

No sol^n

Similarly we can prove No sol^n for.

$pa + qb + rc + sd \leq x$

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— Boolean variables can take only two values 0, 1.

- $k=0 \Rightarrow k'$; $k=1 \Rightarrow k$

- $101 > 011$; $011011 > 010100$
- For $a > p$, condition $\Rightarrow a=1$ and $p=0 \Rightarrow a.p'$
- For $a == p$, condition $\Rightarrow (a=1$ and $p=1)$ or $(a=0$ and $p=0)$
$\Rightarrow ap + a'p'$

— $ab > pq \Rightarrow 11>10$; $11>00$; $11>01$;
$10>01$; $10>00$
$01>00$;

$(a.b.(p'+q')) + a.b'.p' + a'b'p'q'$

$\Rightarrow ap' + abq' + a'bp'q'$
$\Rightarrow ap' + bq'(a+a'p')$

→ 2nd Approach - $(a>p)$ OR $(a==p$ and $(b>q))$

$(a=1; p=0)$ OR $((a=1; p=1; b=1, q=0)$ OR
$(a=0; p=0; b=1, q=0)$

$\Rightarrow ap' + (ap + a'p').bq'$

— $a >= p \Rightarrow (a<p)' \Rightarrow (a'.p)' \Rightarrow a+p'$
$(0<1) \Rightarrow$

— $abc > pqr \Rightarrow (a>p)$ OR $(a=p$ AND $bc > qr)$

SOME P ROOFS

* $k+k'.v \Rightarrow (k+k').(k+v) = k+v$
* $k+k7 \Rightarrow k(1+7) \Rightarrow k$

* $K \cdot U + K' \cdot U = (K + K') \cdot U = U$
* $a \cdot b + a \cdot c = a \cdot (b + c)$
* $(y + z) \cdot (y + w) = y + (z \cdot w)$

* $101 + 011 = 1000$
  $100 + 101 = 1001$
  $011 + 010 = 0101$