

- Recall  $r7 = PC$  ("program counter") keeps track of the address in memory of the next instruction to be executed the processor FSM is responsible for "fetching" the next instruction to be executed.  
 ⇒ the first 3 cycles of every instruction will be used to do this "fetch"
- Recall the states of the processor  $T_0, T_1, T_2, \dots, T_5$

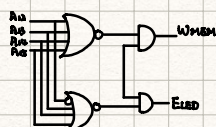
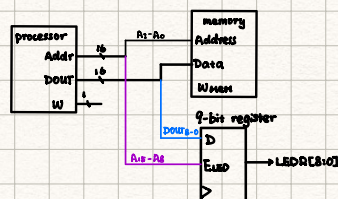
|                        | $T_0$  | $T_1$                        | $T_2$     | $T_3$   | $T_4$ | $T_5$ |
|------------------------|--|------------------------------|-----------|---|-------|-------|
| All instructions fetch | $SEL = PC$<br>$ADDR_{in}$<br>$PC \leftarrow PC + 1$<br>(w/o default) | Wait 1 cycle for memory read | $IR_{in}$ | $mv, mv, add, sub$ work as before but in later cycles ( $T_3$ not $T_1$ ) |       |       |

How to execute the load & store instructions

| $T_0, T_1, T_2$ | $T_3$                             | $T_4$                          | $T_5$                                | instruction  |
|-----------------|-----------------------------------|--------------------------------|--------------------------------------|--|
|                 | $SEL = rY$ ,<br>$ADDR_{in}$ (w/o) | wait 1 cycle                   | $SEL = D_{in}$ ,<br>$rX_{in}$ , Done | $ld\ rX, [rY]$<br>value in memory at<br>$rX \leftarrow$ the address give by $rY$ |
|                 | $SEL = rY$ ,<br>$ADDR_{in}$       | $SEL = rX$ ,<br>$DOUT_{in}, W$ | Done                                 | $st\ rX, [rY]$<br>memory data<br>$rX \leftarrow$ at address $rY$                 |

How to connect the processor to inputs & outputs

- Use the memory connection: memory-mapped input/output
- connect to 9 LEDs on DE1-SoC
- assume these only 256 memory address  $\rightarrow 2^8 = 256$ : only 8 units on the address input of memory.
- we only need  $A_7-A_0$  for memory
- we'll design hardware such that  
 if  $A_{15}A_{14}A_{13}A_{12} = 0000$ , we'll use  $A_7-A_0$  to access memory  
 ... .. 0001, we'll access (change) the 9 LEDs } Use DOUT



Address Decoder: Select which "device" to access based on the address