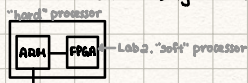


From now on, we'll be using a real processor that exists, permanently on the big Cyclone SoC chip that also contains the FPGA



Brand Version

Hard processor: ARM Cortex M

- More powerful than Lab 2 processor
- All registers are 32 bits wide (not 16)
- There are 16 processor registers (not 8)
- ADDR, DOUT, & wires also 32 bits wide (not 16)
- Memory is organized so each 8 bits (byte) gets its own address

but we can access 32 bits (4 bytes) in a single memory access



* 2³² memory locations = 4 G bytes = 1 G words (1 word = 4 bytes)

- The DE1-SoC has 1 Gbyte = 256 M words
- Exist at addresses: 0 to 3FFF FFFF₁₆
- The other addresses are used for memory-mapped I/O

e.g: LEDR₀₋₀ @ address FF20 0000

HEX₀₋₀ FF20 0020 & FF20 0030
SW₀₋₀ FF20 0040
KEY₀₋₀ FF20 00B0

Example program: Add 4 numbers in memory (put answer in R2)

```
.text
.global _start
_start: MOV R0, #4      R0 ← 4
        MOV R1, #LIST   R1 ← 62 = LIST
        LDR R2, [R1]     R2 ← [62] = 10
        ADD R1, R0       R1 ← R1 + R0 = R1 + 4 = 66
        LDR R3, [R1]     R3 ← [66] = 20
        ADD R2, R3       R2 ← R2 + R3 = 30
        ADD R1, R0
        LDR R3, [R1]
        ADD R2, R3
        ADD R1, R0
        LDR R3, [R1]
        ADD R2, R3
END: B    END
```

LIST: .word 10, 20, 30, 40 LIST: Address 62 66 70 74 78 82 86 90 94 98 102 106 110 114 118 122 126 130 134 138 142 146 150 154 158 162 166 170 174 178 182 186 190 194 198 202 206 210 214 218 222 226 230 234 238 242 246 250 254 258 262 266 270 274 278 282 286 290 294 298 302 306 310 314 318 322 326 330 334 338 342 346 350 354 358 362 366 370 374 378 382 386 390 394 398 402 406 410 414 418 422 426 430 434 438 442 446 450 454 458 462 466 470 474 478 482 486 490 494 498 502 506 510 514 518 522 526 530 534 538 542 546 550 554 558 562 566 570 574 578 582 586 590 594 598 602 606 610 614 618 622 626 630 634 638 642 646 650 654 658 662 666 670 674 678 682 686 690 694 698 702 706 710 714 718 722 726 730 734 738 742 746 750 754 758 762 766 770 774 778 782 786 790 794 798 802 806 810 814 818 822 826 830 834 838 842 846 850 854 858 862 866 870 874 878 882 886 890 894 898 902 906 910 914 918 922 926 930 934 938 942 946 950 954 958 962 966 970 974 978 982 986 990 994 998 1000