

DA RESTITUIRE INSIEME AGLI ELABORATI e A TUTTI I FOGLI
 → NON USARE FOGLI NON TIMBRATI
 → ANDARE IN BAGNO PRIMA DELL'INIZIO DELLA PROVA
 → NO FOGLI PERSONALI, NO TELEFONI, SMARTPHONE, ETC

SVOLGIMENTO DELLA PROVA:

□ PER GLI STUDENTI DI "ARCHITETTURA DEI CALCOLATORI – A.A. 2015/16, 16/17, 17/18, 18/19": es. N.1+2+3+7.

NOTA: per l'esercizio 7 dovranno essere consegnati DUE files: il file del programma VERILOG e il file relativo all'output (screenshot o copy/paste)

- 1) [14/30] Trovare il codice assembly MIPS corrispondente al seguente programma (usando solo e unicamente istruzioni della tabella sottostante e rispettando le convenzioni di utilizzazione dei registri dell'assembly MIPS riportate qua sotto per riferimento).

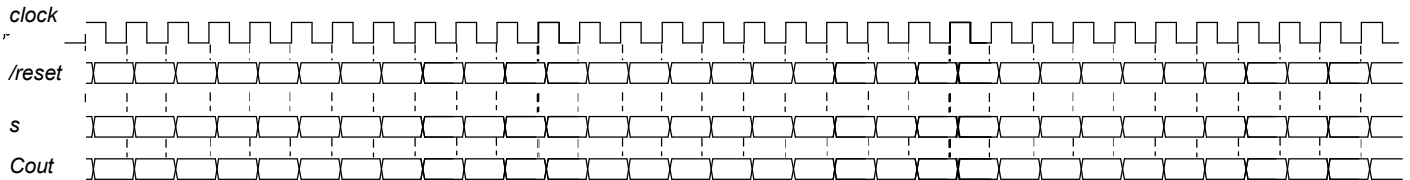
```
unsigned int reverseBits(unsigned int num)
{
    unsigned int NO_OF_BITS = 32; //sizeof(num) * 8;
    unsigned int reverse_num = 0, i, temp;

    for (i = 0; i < NO_OF_BITS; i++)
    {
        temp = (num & (1 << i));
        if(temp)
            reverse_num |= (1 << ((NO_OF_BITS - 1) - i));
    }

    return reverse_num;
}

int main()
{
    unsigned int x = 2;
    unsigned int y = reverseBits(x);
    print_int(y);
    print_string("\n");
    print_int(reverseBits(y));
}
```

- 2) [5/30] Si consideri una cache di dimensione 256B e a 4 vie di tipo write-back/write-non-allocate. La dimensione del blocco e' 16 byte, il tempo di accesso alla cache e' 4 ns e la penalita' in caso di miss e' pari a 40 ns, la politica di rimpiazzamento e' FIFO. Il processore effettua i seguenti accessi in cache, ad indirizzi al byte: 126, 112, 162, 110, 139, 160, 114, 223, 221, 240, 215, 312, 415, 522, 690, 715, 830, 911, 1010, 1117, 1230, 122. Tali accessi sono alternativamente letture e scritture. Per la sequenza data, ricavare il tempo medio di accesso alla cache, riportare i tag contenuti in cache al termine, i bit di modifica (se presenti) e la lista dei blocchi (ovvero il loro indirizzo) via via eliminati durante il rimpiazzamento ed inoltre in corrispondenza di quale riferimento il blocco e' eliminato.
- 3) [2/30] Rappresentare la tabella di verità di un encoder a 4 ingressi e 2 uscite e sintetizzarlo tramite mappe di Karnaugh.
- 7) [9/30] **Realizzare** in Verilog un sommatore a 4-bit di tipo carry-look-ahead. Il testbench e' dato. **Tracciare il diagramma di temporizzazione** come verifica della correttezza dell'unità riportando i segnali clock, /reset, uscita S e Cout (carry in uscita al sommatore) per la durata complessiva (45ns). Nota: si può svolgere l'esercizio su carta oppure con ausilio del simulatore salvando una copia dell'output (diagramma temporale) e del programma Verilog su USB-drive del docente

**Testbench:**

```
`timescale 1ns/1ps
module cla4 testbench;
    reg reset; initial begin reset =0; #2 reset =1; #600; $stop; end
    reg clock; initial clock<=0; _always #5 clock<=!clock;
    reg[3:0] a, b; reg cin; wire cout; wire [3:0] s;
    initial begin cin <=0;
        @(posedge clock); a<=7; b<=7; @(posedge clock); a<=7; b<=9;
        @(posedge clock); a<=9; b<=2; @(posedge clock); a<=7; b<=3;
        $finish;
    end
    cla adder_4bit CLA4(a,b,cin,s,cout);
endmodule
```

Instructions				
Opcod+Funct (hexadecimal)	Instruction	Example	Meaning	Comments
00+20/00+21	add	add/addu \$1,\$2,\$3	\$1 = \$2 + \$3	(signed/unsigned) 3 operands; exception possible
00+22/00+23	subtract	sub/subu \$1,\$2,\$3	\$1 = \$2 - \$3	(signed/unsigned) 3 operands; exception possible
08/09	add immediate	addi/addiu \$1,\$2,100	\$1 = \$2 + 100	(signed/unsigned) + constant ; exception possible
00+18/00+19	multiplication	mult/multu \$1,\$2	Hi,Lo= \$1 x \$2	(signed/unsigned) 64-bit Product ; result in Hi,Lo
00+1A/00+1B	division	div/divu \$1,\$2	Hi= \$1 % \$2, Lo = \$1 / \$2	(signed/unsigned) division
00+10/00+12	move from Hi / move from Lo	mfhi/mflo \$1	\$1 = Hi (\$1 = Lo)	Create copy of Hi (Create a copy of Lo)
00+2A/00+2B	set on less than	slt/sltu \$1,\$2,\$3	if (\$2 < \$3) \$1 = 1; else \$1 = 0	(signed/unsigned) compare \$2 and \$3 (less than)
0A/0B	set on less than immediate	slti/sltiu \$1,\$2,100	if (\$2 < 100) \$1 = 1; else \$1 = 0	(signed/unsigned) compare \$2 and constant (less than)
00+24/25/26/27	and / or / xor / nor	and/or/xor/nor \$1,\$2,\$3	\$1 = \$2&\$3 / \$2 \$3 / \$2^\$3 / !(\$2 \$3)	3 register operands; Logical AND/OR/XOR/NOR
0C/0D/0E	and / or / xor immediate	andi/ori/xori \$1,\$2,100	\$1 = \$2 & 100 / \$2 100 / \$2 ^100	Logical AND/OR/XOR register, constant
00+00	shift left logical	sll \$1,\$2,10	\$1 = \$2 << 10	Shift left by constant
00+02/00+03	lft right (=logical,a=arithmetic)	srl/sra \$1,\$2,10	\$1 = \$2 >> 10	Shift right by constant (for arithmetic: sign is preserved)
00+04	shift left logical	sllv \$1,\$2,10	\$1 = \$2 << \$3	Shift left by variable
00+06/00+07	lft right (=logical,a=arithmetic)	srlv/srav \$1,\$2,10	\$1 = \$2 >> \$3	Shift right by variable (for arithmetic: sign is preserved)
23/20	load word / load byte	lw/lb \$1,100(\$2)	\$1 = Memory[\$2+100]	Data from memory to register
24	load byte unsigned	lbu \$1,100(\$2)	\$1 = Memory[\$2+100]	Data from mem. To reg.; no sign extension
2B/28	store word / store byte	sw/sb \$1,100(\$2)	Memory[\$2+100] = \$1	Data from register to memory
0F	load upper immediate	lui \$1,0x1234	\$1=0x1234'0000	load most significant 16 bits
PSEUDOINSTRUCTION	load address	la \$1,var	\$1 = &var	Load address of var (lui \$1,H16(&var);ori \$1, L16(&var)) H16/L16=high/low 16 bits of &var
02	jump	j 10000	go to 10000	Jump to target address
00+08	jump register	jr \$31	go to \$31	For switch, procedure return
03	jump and link	jal 10000	\$31 = PC + 4; go to 10000	For procedure call
04	branch on equal	beq \$1,\$2,100	if (\$1 == \$2) go to PC+4+100	Equal test; PC relative branch
05	branch on not equal	bne \$1,\$2,100	if (\$1 != \$2) go to PC+4+100	Not equal test; PC relative
00+0C	syscall	syscall	call OS service \$v0	See table of system calls below
10+10,rs=10	rfe	rfe	shift right (k,e) bits in STATUS reg	Exit Kernel Mode, Enable Interrupts
PSEUDOINSTRUCTION	branch unconditional	b 100	go to PC+4+100	PC relative branch (e.g., beq \$0,\$0,100)
PSEUDOINSTRUCTION	no operation	nop	do nothing	Do nothing (e.g. sll \$0,\$0,0)
30	load-linked	ll \$1,100(\$2)	\$1=Memory[\$2+100]	Read and start to monitor the given memory location
38	store-conditional	sc \$1,100(\$2)	Memory[\$2+100]=\$1 or →	return 0 if a coherence action happens since the previous ll (\$1 must be different from 0)
11+00 fmt=10/11	add.s / add.d	add.x \$f0,\$f2,\$f4	\$f0=\$f2+\$f4	Single and double precision add
11+01 fmt=10/11	sub.s / sub.d	sub.x \$f0,\$f2,\$f4	\$f0=\$f2-\$f4	Single and double precision subtraction
11+02 fmt=10/11	mul.s / mul.d	mul.x \$f0,\$f2,\$f4	\$f0=\$f2*\$f4	Single and double precision multiplication
11+03 fmt=10/11	div.s / div.d	div.x \$f0,\$f2,\$f4	\$f0=\$f2/\$f4	Single and double precision division
11+05 fmt=10/11	abs.s / abs.d	abs.x \$f0,\$f2	\$f0=ABS(\$f2)	Single and double precision absolute value
11+06 fmt=10/11	mov.s / mov.d	mov.x \$f0,\$f2	\$f0←\$f2	Single and double precision move
11+07 fmt=10/11	neg.s / neg.d	neg.x \$f0,\$f2	\$f0= - (\$f2)	Single and double precision opposite value
11+3C (31,32,3D,3E,3F) fmt=10/11	c.lts / c.lt.d (ne,eq,gt,le,ge)	c.lt.x \$f0,\$f2	Temp=(\$f0<\$f2)	Single and double: compare \$f0 and \$f2 <=,!=,>,<=>=
11+00 fmt=4/0	move to/from coprocessor 1	mtc1/mfc1 \$1,\$f2	\$f2=\$1 / \$1=\$f2	Move \$1 to/from C1 reg. \$f2 (no conversion)
10+00 fmt=4/0	move to/from coprocessor 0	mtc0/mfc0 \$1,\$f2	\$f2=\$1 / \$1=\$f2	Move \$1 to/from C0 reg. \$f2 (no conversion)
11+00 fmt=6/2	move to/from control reg of cop.1	ctc1/cfc1 \$1,\$cf2	\$cf2=\$1 / \$1=\$cf2	Move \$1 to/from C1-CONTROL register
11 fmt=8, ft=1/0	branch on true/false	bc1t/bc1f label	If (Temp == true/false) go to label	Temp is 'Condition-Code'
31/39	load/store floating point (32bit)	lwc1/swc1 \$f0,0(\$1)	\$f0←Memory[\$1] / Memory[\$1]←\$f0	Data from FP (C1) register to memory
11+21, fmt=10/11+22, fmt=11	convert from/to single to/from double	cvt.d.s/cvt.s.d \$f0,\$f2	\$f0=(double)\$f2/\$f0=(single)\$f2	Type conversion
11+24, fmt=11/11+20	convert from/to single to/from integer	cvt.w.s/cvt.s.w \$f1,\$f0	\$f1=(int)\$f0 / \$f0=(single)\$f2	Type conversion

Register Usage

Name	Reg. Num.	Usage	Name	Reg.Num.	Usage	Reg. Num.	Usage
\$zero	0	The constant value 0	\$v0-\$v1	2-3	Results	\$f0, \$f2	Return values
\$s0-\$s7	16-23	Saved	\$fp, \$sp	30,29	frame pointer, stack pointer	\$f12,\$f14	Function arguments
\$t0-\$t9	8-15,24-25	Temporaires	\$ra, \$gp	31,28	return address, global pointer	\$f20,\$f22,\$f24,\$f26,\$f28,\$f30	Saved registers
\$a0-\$a3	4-7	Arguments	\$k0-\$k1	26,27	Kernel usage	\$f4,\$f6,\$f8,\$f10,\$f16,\$f18	Temporaries registers

System calls

Service Name	Service Num. (\$v0)	INPUT Arguments	OUTPUT Arguments
print int	1	\$a0=integer to print	---
print float	2	\$f12=float to print	---
print double	3	(\$f12,\$f13)=double to print	---
print string	4	\$a0=address of ASCIIZ string to print	---
read int	5	---	\$v0=integer
read float	6	---	\$f0=float
read double	7	---	\$f0-f1=double
read string	8	\$a0=address of input buffer, \$a1=max characters to read	---
sbrk	9	\$a0=Number of bytes to be allocated	\$v0=pointer to the allocated memory
exit	10	---	---