

Laboratory 1

Expected delivery of lab_01.zip including:

- Program_0.s
- Program_1.s
- lab_01.pdf (fill and export this file to pdf)

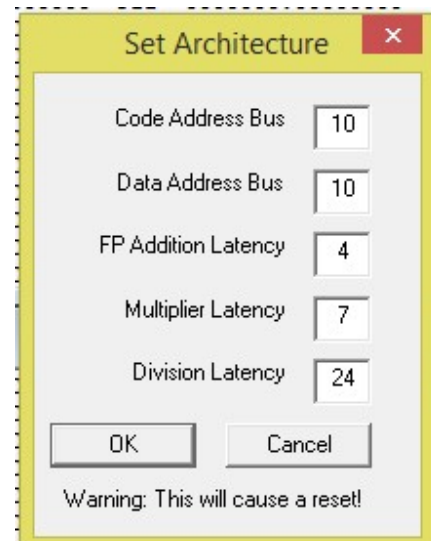
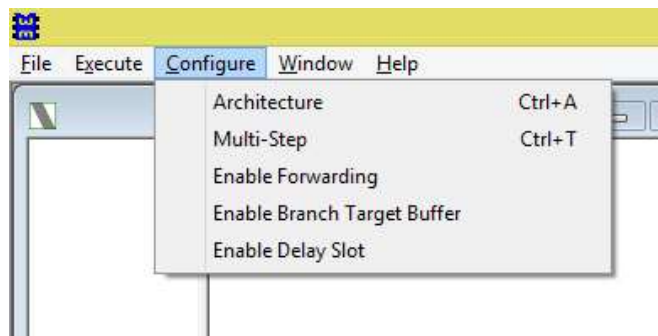
Please, configure the winMIPS64 processor architecture with the *Base Configuration* provided in the following:

- Integer ALU: 1 clock cycle
- Data memory: 1 clock cycle
- Branch delay slot: 1 clock cycle
- Code address bus: 12
- Data address bus: 12
- Pipelined FP arithmetic unit (latency): 6 stages
- Pipelined FP multiplier unit (latency): 8 stages
- FP divider unit (latency): not pipelined unit, 28 clock cycles
- Forwarding optimization is disabled
- Branch prediction is disabled
- Branch delay slot optimization is disabled.

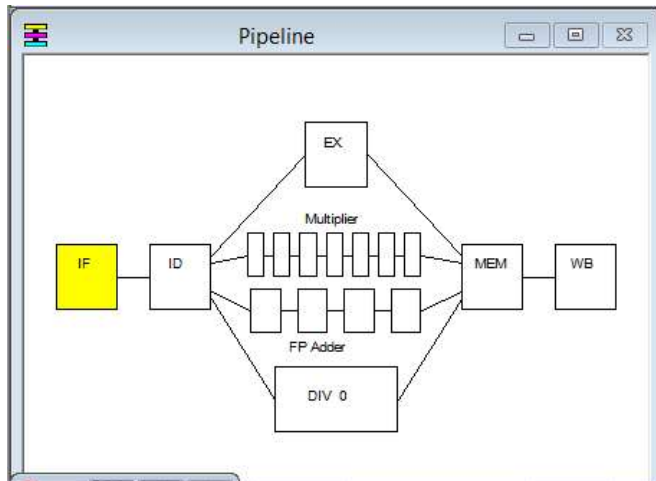
Use the Configure menu:

- remove the flags (where activating Enable options)
- Browse the Architecture menu →

Modify the defaults Architectural parameters (where needed)



← Verify in the Pipeline window that the configuration is effective



1) Exercise your assembly skills.

To write an assembly program called **program_0.s (to be delivered)** for the MIPS64 architecture and to execute it.

The program must:

1. Given one array (a), find how many times the 8-bit unsigned value `val=0x2f` is included in it. The array contains 100 unsigned 16-bit integer numbers. Looks for the occurrence in both the most significant **byte** and the least significant **byte** of the 16-bit integer numbers. Store the result in a 8-bit variable (`res`).

Example (with only 10 elements):

`a = 5, 0x01a1, 0x2f, 17, 0x2fe0, 1, 0x96a4, 0x2f, 3, 0x2f`
`res = 4`

2) Exercise your assembly skills and use the main components of the simulator:

To write an assembly program called **program_1.s (to be delivered)** for the MIPS64 architecture and to execute it.

The program must:

1. Given 2 arrays (a and b), compute their signed sum and store each result in a third array (i.e., `c[i] = a[i] + b[i]`). Each array contains 30 8-bit integer numbers.
2. Create two variables allocated in memory: `threshold_high` and `threshold_low`. For each element `c[i]`, check whether it is greater or lesser than a fixed threshold: if it is greater, increase `threshold_high`, else increase `threshold_low`. Assume the threshold is equal to 0x0. Note that `0x00` belongs to `threshold_high`.
3. Search for both the maximum and minimum in the array c. The program saves the obtained value in two variables allocated in memory, called `max` and `min` respectively.

Identify and use the main components of the simulator:

- a. Running the *WinMIPS* simulator
 - Launch the graphic interface

...\winMIPS64\winmips64.exe

- b. Assembly and check your program:
 - Load the program from the **File→Open** menu (*CTRL-O*). In the case the of errors, you may use the following command in the command line to compile the program and check the errors:
...\winMIPS64\asm program_1.s
- c. Run your program step by step (*F7*), identifying the whole processor behavior in the six simulator windows:
Pipeline, Code, Data, Register, Cycles and Statistics
- d. Repeat the process (a-b-c) for program_0.s

Table 1: **Programs performance for the processor's base configurations**

	Number of clock cycles
program_0.S	1496
program_1.S	765

3) Perform execution time measurements.

Search in the winMIPS64 folder the following benchmark programs:

- a. isort.s
- b. mult.s
- c. program_0.s (your program)
- d. program_1.s (your program)

Starting from the basic configuration with no optimizations, compute by simulation the number of cycles required to execute these programs (and then the weighted arithmetic mean). Assume a processor frequency of 5MHz. Then, vary the program weights as specified by the following Configurations. Compute the weighted arithmetic mean for every case and fill the table below **(fill all required data in the table before exporting this file to pdf format to be delivered):**

- 1) Configuration 1
Assume that the weight of all programs is the same (25%).
- 2) Configuration 2
Assume that the weight of the program program_0.s is 55%.
- 3) Configuration 3
Assume that the weight of the program isort.s is 40%.

Table 2: **Processor performance for different weighted programs**

Program	Conf. 1	Conf. 2	Conf. 3
isort.s	2302,05	1381,23	3683,28
mult.s	94	56,4	75,2
program_0.s	74,8	164,56	59,84
program_1.s	38,25	22,95	30,6
TOTAL TIME (us)	2509,55	1625,14	3848,92

For time computations, use a clock frequency of 5MHz.

Appendix: winMIPS64 Instruction Set

WinMIPS64

The following assembler directives are supported

.data - start of data segment
.text - start of code segment
.code - start of code segment (same as .text)
.org <n> - start address
.space <n> - leave n empty bytes
.ascii <s> - enters zero terminated ascii string
.ascii <s> - enter ascii string
.align <n> - align to n-byte boundary
.word <n1>,<n2>.. - enters word(s) of data (64-bits)
.byte <n1>,<n2>.. - enter bytes
.word32 <n1>,<n2>.. - enters 32 bit number(s)
.word16 <n1>,<n2>.. - enters 16 bit number(s)
.double <n1>,<n2>.. - enters floating-point number(s)

where <n> denotes a number like 24, <s> denotes a string like "fred", and
<n1>,<n2>.. denotes numbers seperated by commas.

The following instructions are supported

lb - load byte
lbu - load byte unsigned
sb - store byte
lh - load 16-bit half-word
lhu - load 16-bit half word unsigned
sh - store 16-bit half-word
lw - load 32-bit word
lwu - load 32-bit word unsigned
sw - store 32-bit word
ld - load 64-bit double-word
sd - store 64-bit double-word
ld - load 64-bit floating-point
sd - store 64-bit floating-point
halt - stops the program

daddi - add immediate
daddui - add immediate unsigned
andi - logical and immediate
ori - logical or immediate
xori - exclusive or immediate
lui - load upper half of register immediate
slti - set if less than or equal immediate
sltiu - set if less than or equal immediate unsigned

beq - branch if pair of registers are equal
bne - branch if pair of registers are not equal
beqz - branch if register is equal to zero
bnez - branch if register is not equal to zero

j - jump to address
jr - jump to address in register
jal - jump and link to address (call subroutine)
jalr - jump and link to address in register (call subroutine)

dsl - shift left logical
dsrl - shift right logical
dsra - shift right arithmetic
dslv - shift left logical by variable amount
dsrlv - shift right logical by variable amount
dsrav - shift right arithmetic by variable amount

movz - move if register equals zero
movn - move if register not equal to zero
nop - no operation
and - logical and
or - logical or
xor - logical xor
slt - set if less than
sltu - set if less than unsigned
dadd - add integers
daddu - add integers unsigned
dsub - subtract integers
dsubu - subtract integers unsigned

add.d - add floating-point
sub.d - subtract floating-point
mul.d - multiply floating-point
div.d - divide floating-point
mov.d - move floating-point
cvt.d.l - convert 64-bit integer to a double FP format
cvt.l.d - convert double FP to a 64-bit integer format
c.lt.d - set FP flag if less than
c.le.d - set FP flag if less than or equal to
c.eq.d - set FP flag if equal to
bc1f - branch to address if FP flag is FALSE
bc1t - branch to address if FP flag is TRUE
mtc1 - move data from integer register to FP register
mfc1 - move data from FP register to integer register