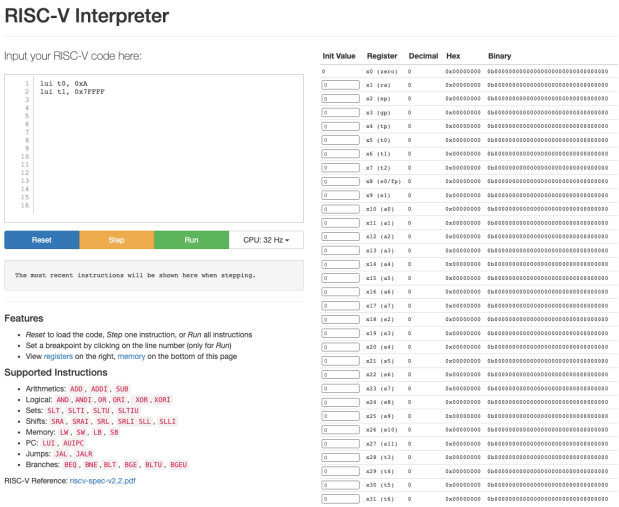
# CSC 411

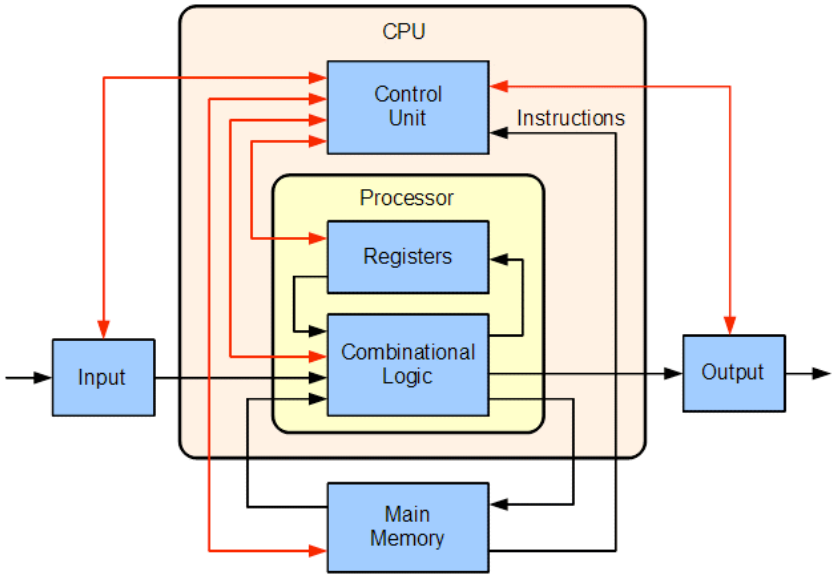
## Computer Organization (Spring 2023)
## Lecture 7: Executing Instructions

**Prof. Marco Alvarez, University of Rhode Island**

# RISC-V interpreter

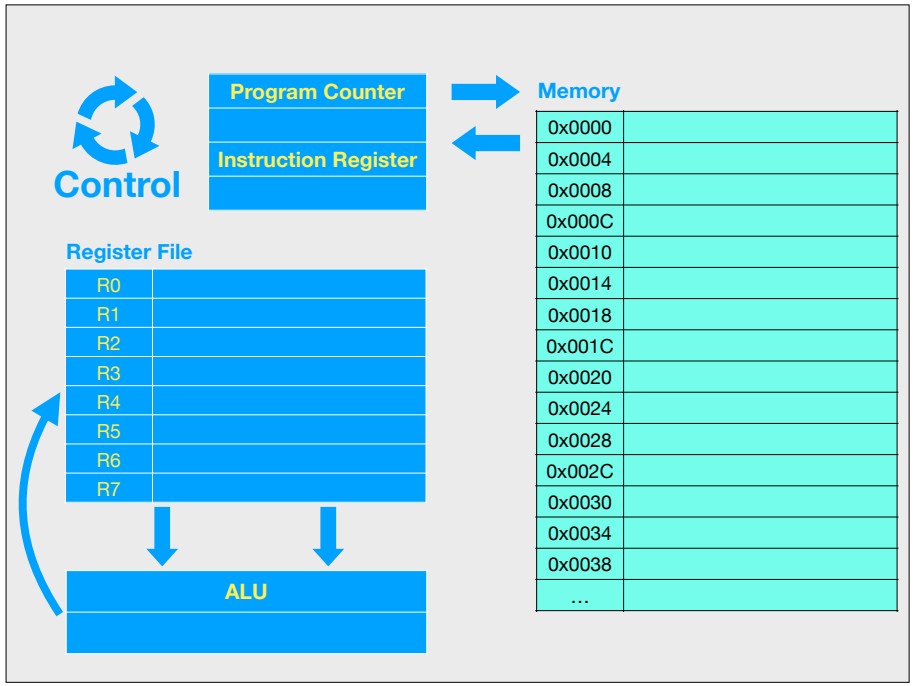


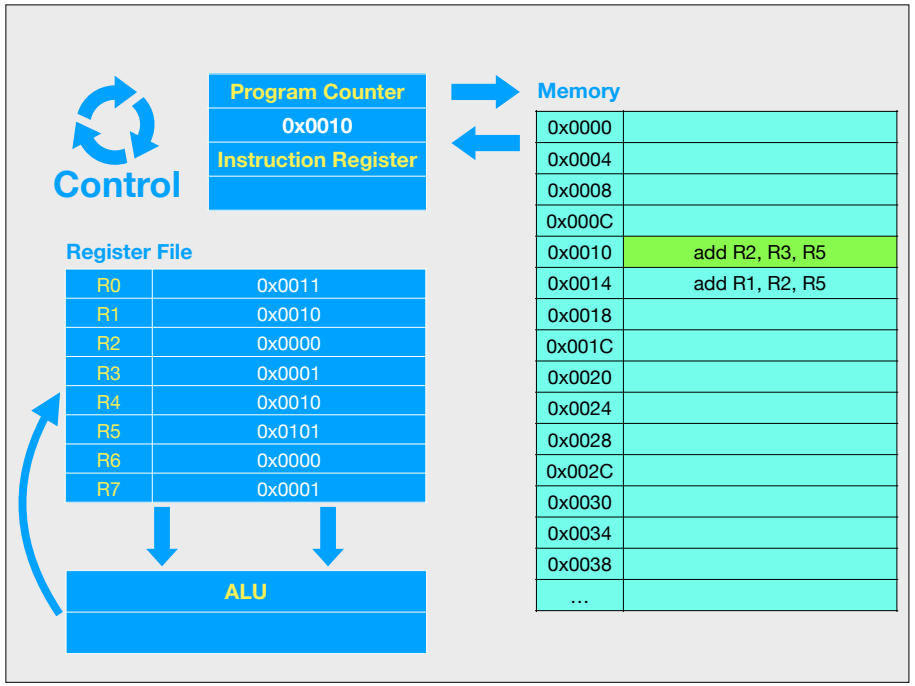

https://www.cs.cornell.edu/courses/cs3410/2019sp/riscv/interpreter/

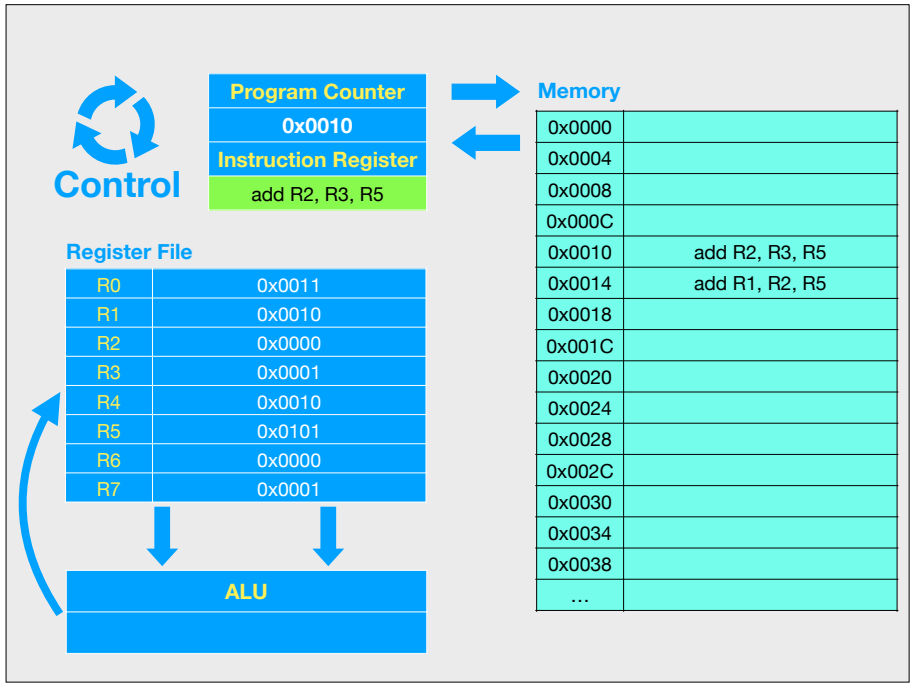


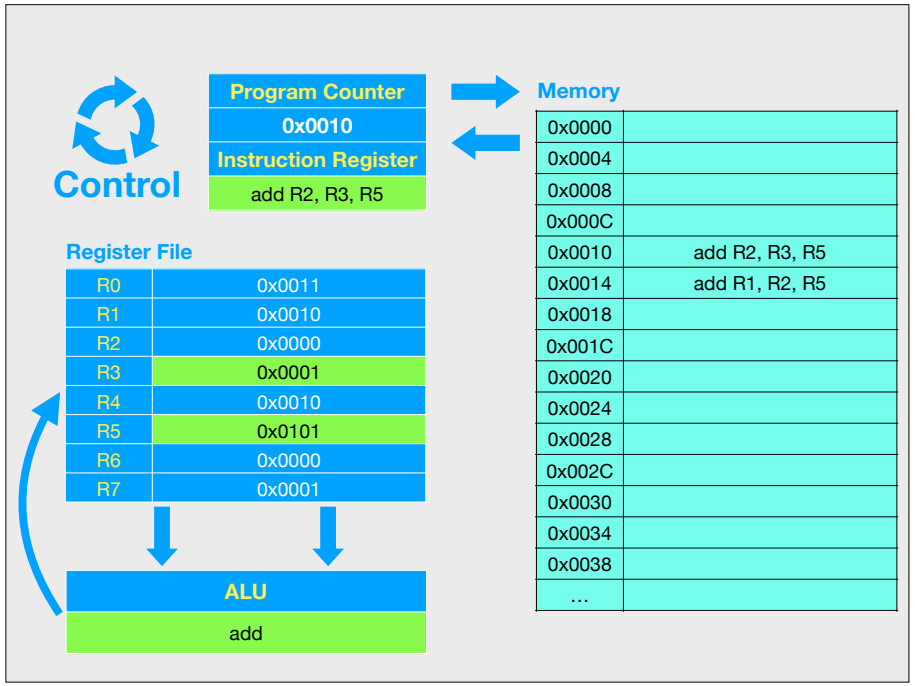

https://en.wikipedia.org/wiki/Computer_architecture

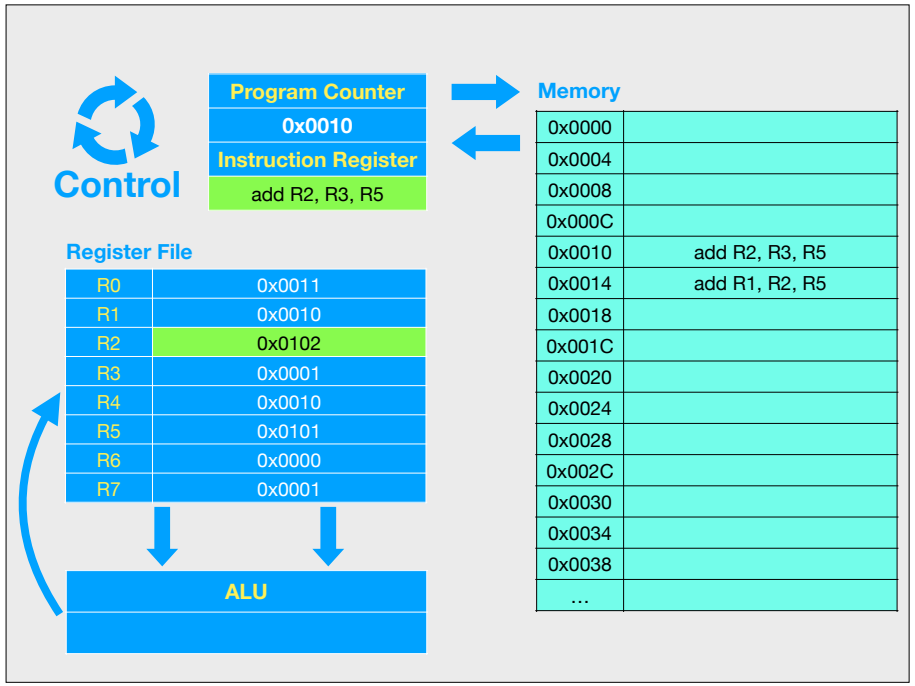
# Executing instructions

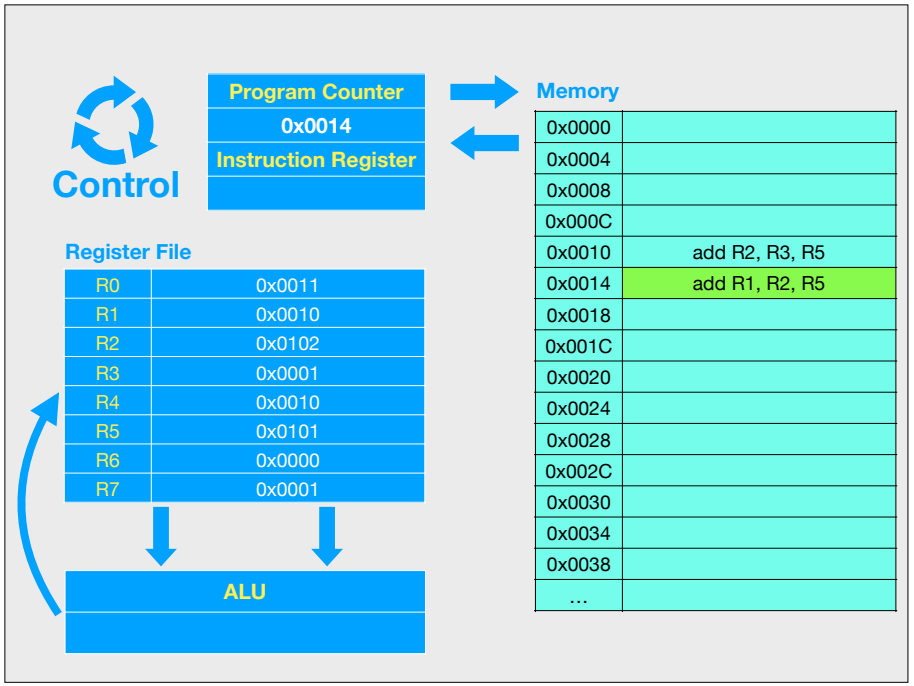

Control
Program Counter
Instruction Register
Memory
0x0000
0x0004
0x0008
0x000C
0x0010
0x0014
0x0018
0x001C
0x0020
0x0024
0x0028
0x002C
0x0030
0x0034
0x0038
...
Register File
R0
R1
R2
R3
R4
R5
R6
R7
ALU

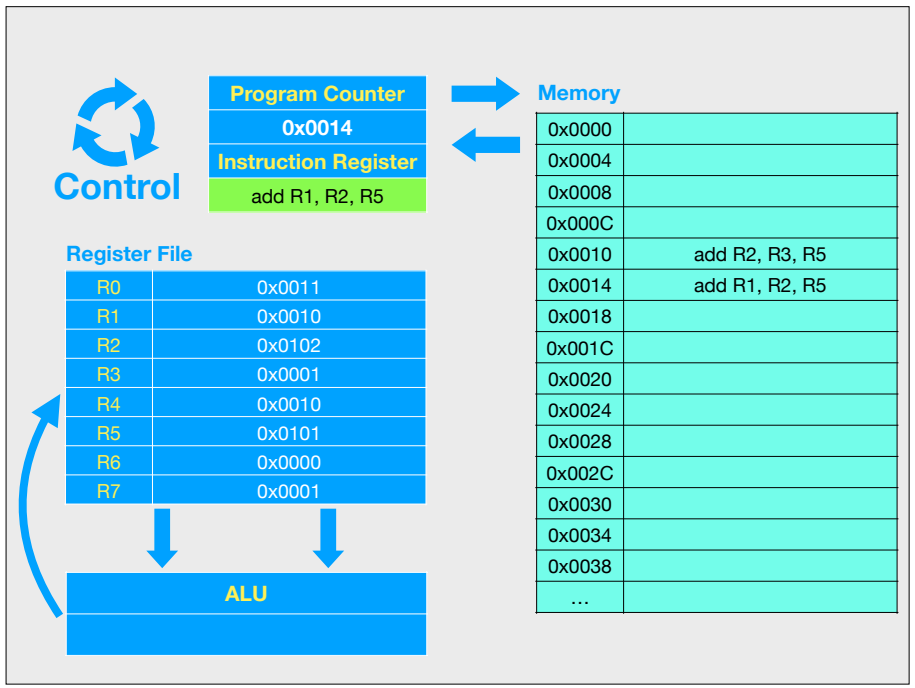

Control
Program Counter
0x0010
Instruction Register
Memory
0x0000
0x0004
0x0008
0x000C
0x0010
add R2, R3, R5
0x0014
add R1, R2, R5
0x0018
0x001C
0x0020
0x0024
0x0028
0x002C
0x0030
0x0034
0x0038
...
Register File
R0
0x0011
R1
0x0010
R2
0x0000
R3
0x0001
R4
0x0010
R5
0x0101
R6
0x0000
R7
0x0001
ALU

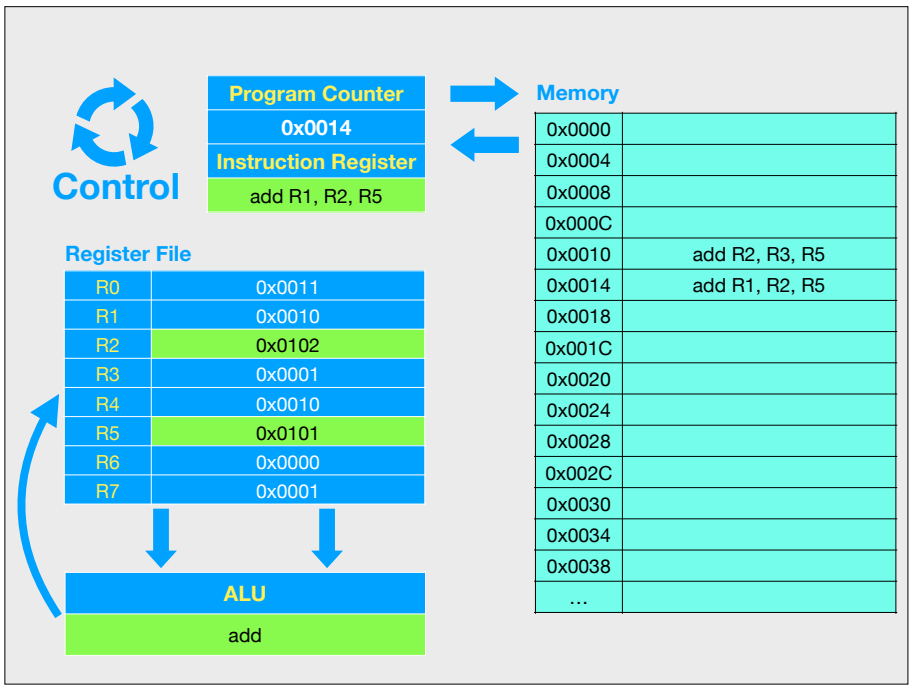

Control
Program Counter
0x0010
Instruction Register
add R2, R3, R5
Memory
0x0000
0x0004
0x0008
0x000C
0x0010
add R2, R3, R5
0x0014
add R1, R2, R5
0x0018
0x001C
0x0020
0x0024
0x0028
0x002C
0x0030
0x0034
0x0038
...
Register File
R0
0x0011
R1
0x0010
R2
0x0000
R3
0x0001
R4
0x0010
R5
0x0101
R6
0x0000
R7
0x0001
ALU

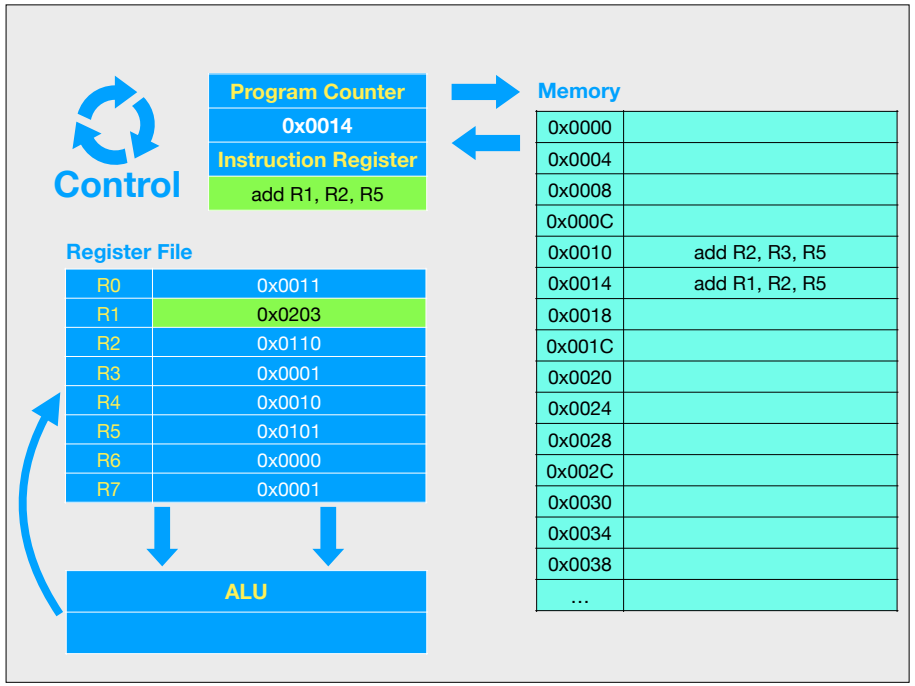

Control
Program Counter
0x0010
Instruction Register
add R2, R3, R5
Memory
0x0000
0x0004
0x0008
0x000C
0x0010
add R2, R3, R5
0x0014
add R1, R2, R5
0x0018
0x001C
0x0020
0x0024
0x0028
0x002C
0x0030
0x0034
0x0038
...
Register File
R0
0x0011
R1
0x0010
R2
0x0000
R3
0x0001
R4
0x0010
R5
0x0101
R6
0x0000
R7
0x0001
ALU
add


Control
Program Counter
0x0010
Instruction Register
add R2, R3, R5
Memory
Register File
R0 0x0011
R1 0x0010
R2 0x0102
R3 0x0001
R4 0x0010
R5 0x0101
R6 0x0000
R7 0x0001
ALU
0x0000
0x0004
0x0008
0x000C
0x0010 add R2, R3, R5
0x0014 add R1, R2, R5
0x0018
0x001C
0x0020
0x0024
0x0028
0x002C
0x0030
0x0034
0x0038
...

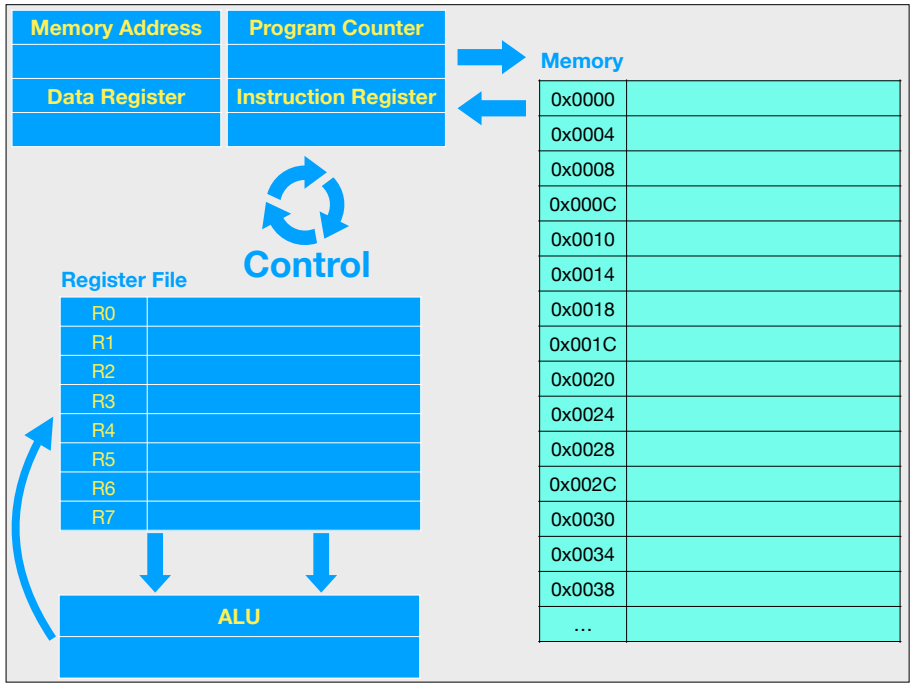

Control
Program Counter
0x0014
Instruction Register
Memory
Register File
R0 0x0011
R1 0x0010
R2 0x0102
R3 0x0001
R4 0x0010
R5 0x0101
R6 0x0000
R7 0x0001
ALU
0x0000
0x0004
0x0008
0x000C
0x0010 add R2, R3, R5
0x0014 add R1, R2, R5
0x0018
0x001C
0x0020
0x0024
0x0028
0x002C
0x0030
0x0034
0x0038
...

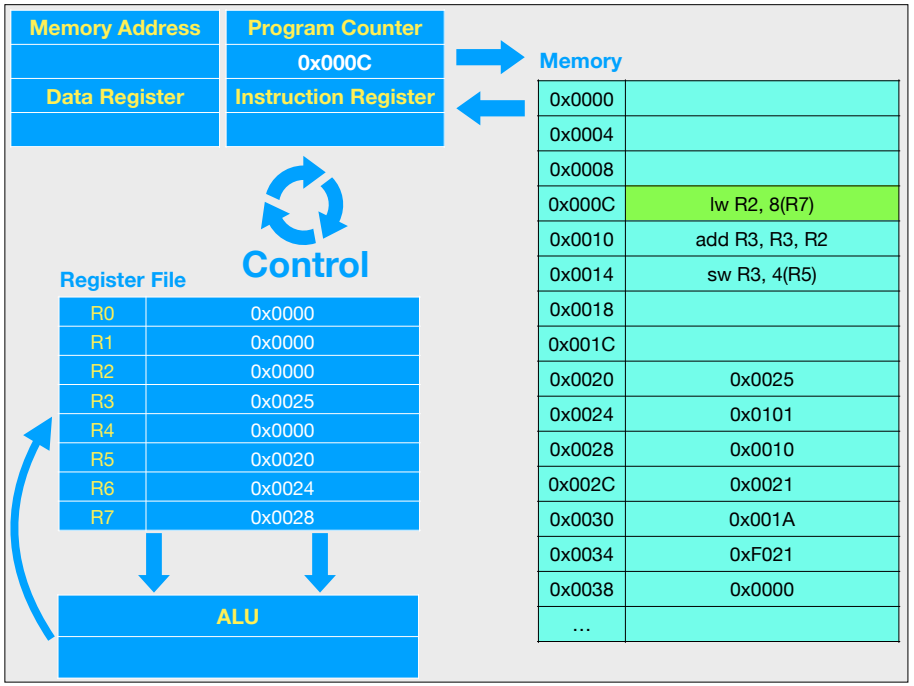

Control
Program Counter
0x0014
Instruction Register
add R1, R2, R5
Memory
Register File
R0 0x0011
R1 0x0010
R2 0x0102
R3 0x0001
R4 0x0010
R5 0x0101
R6 0x0000
R7 0x0001
ALU
0x0000
0x0004
0x0008
0x000C
0x0010 add R2, R3, R5
0x0014 add R1, R2, R5
0x0018
0x001C
0x0020
0x0024
0x0028
0x002C
0x0030
0x0034
0x0038
...

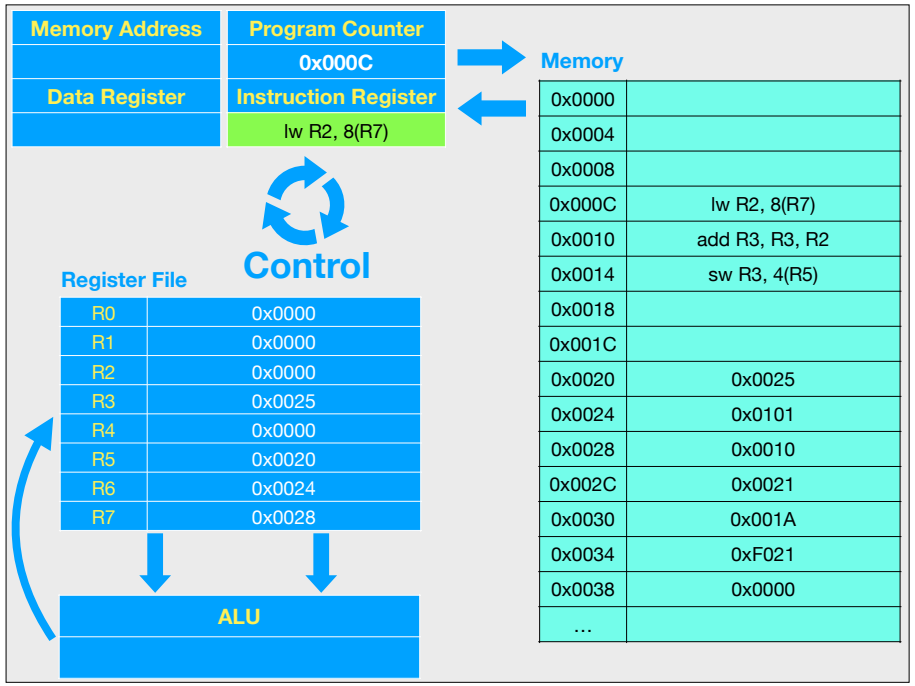

Control
Program Counter
0x0014
Instruction Register
add R1, R2, R5
Memory
Register File
R0 0x0011
R1 0x0010
R2 0x0102
R3 0x0001
R4 0x0010
R5 0x0101
R6 0x0000
R7 0x0001
ALU
add
0x0000
0x0004
0x0008
0x000C
0x0010 add R2, R3, R5
0x0014 add R1, R2, R5
0x0018
0x001C
0x0020
0x0024
0x0028
0x002C
0x0030
0x0034
0x0038
...

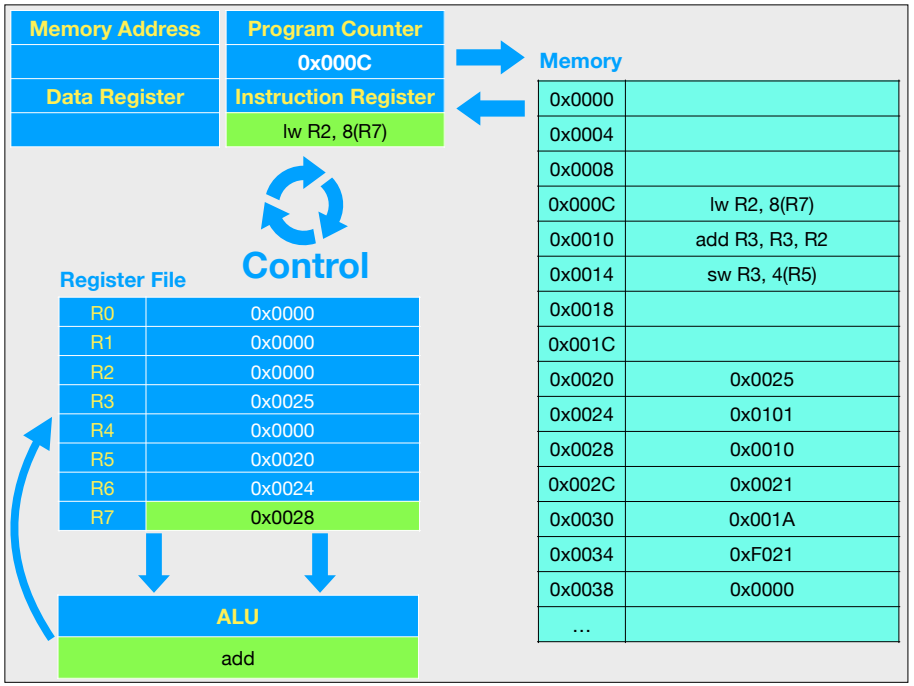


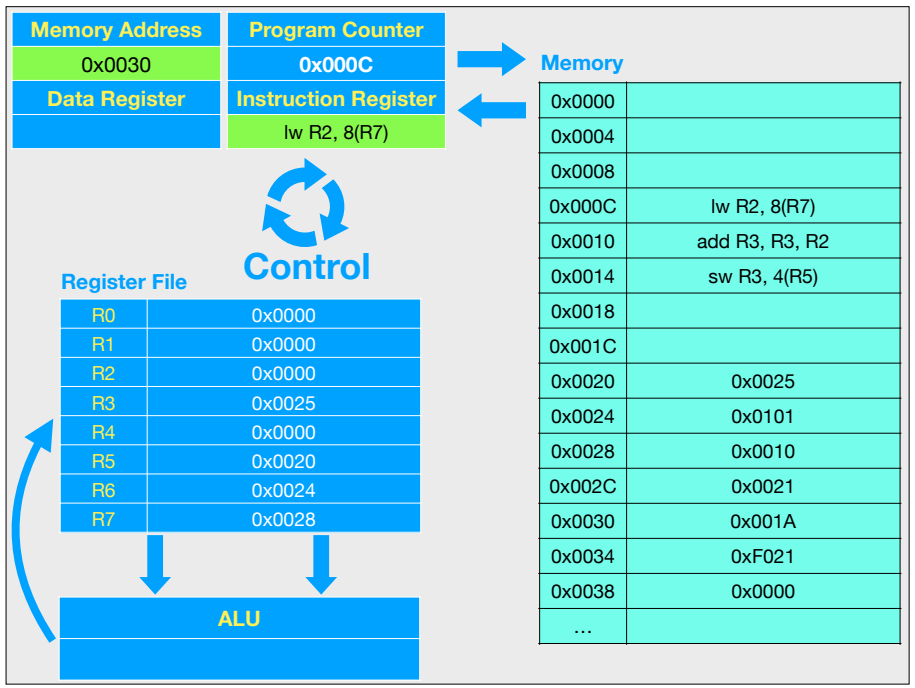

# Executing memory instructions

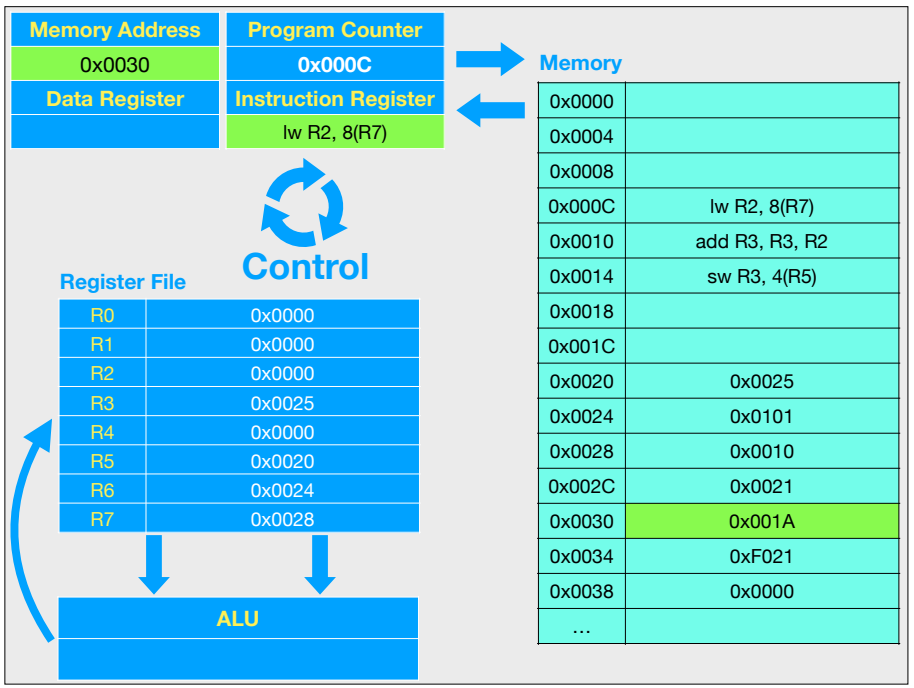


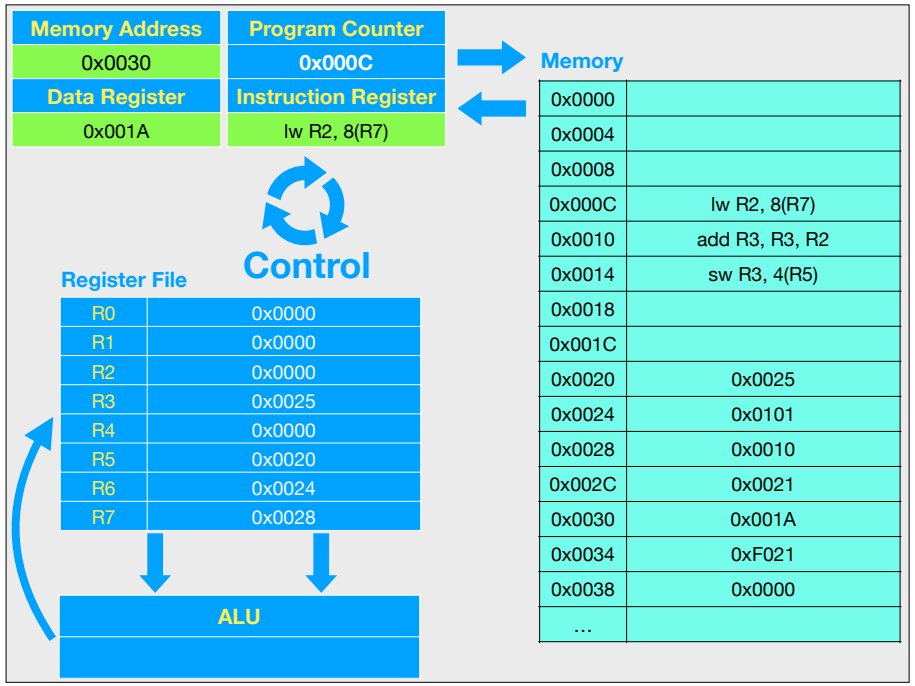



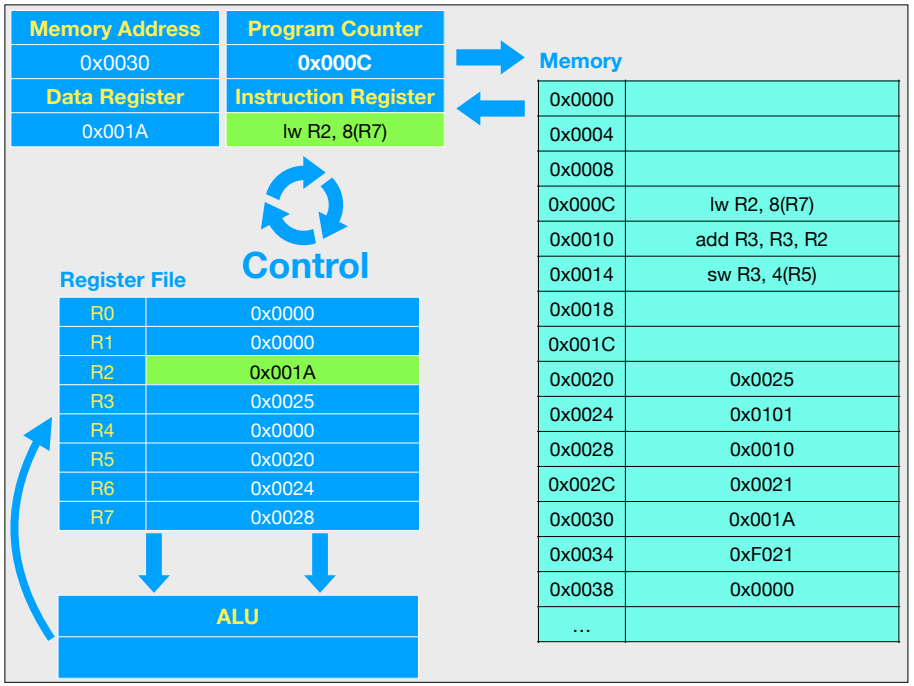

Memory Address
Program Counter
0x000C
Data Register
Instruction Register
lw R2, 8(R7)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x0000
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

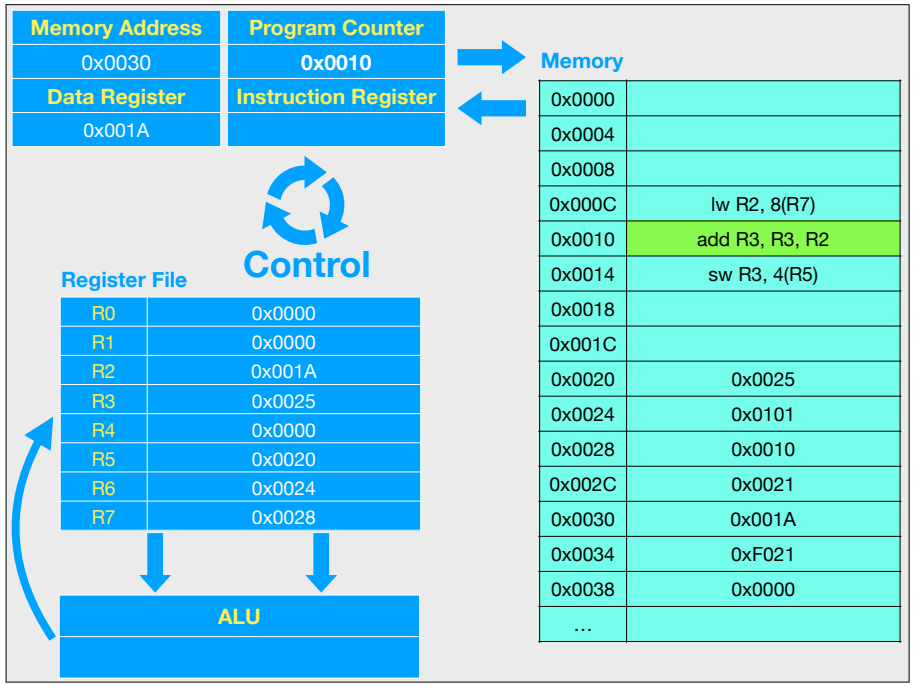

Memory Address
Program Counter
0x000C
Data Register
Instruction Register
lw R2, 8(R7)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x0000
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU
add

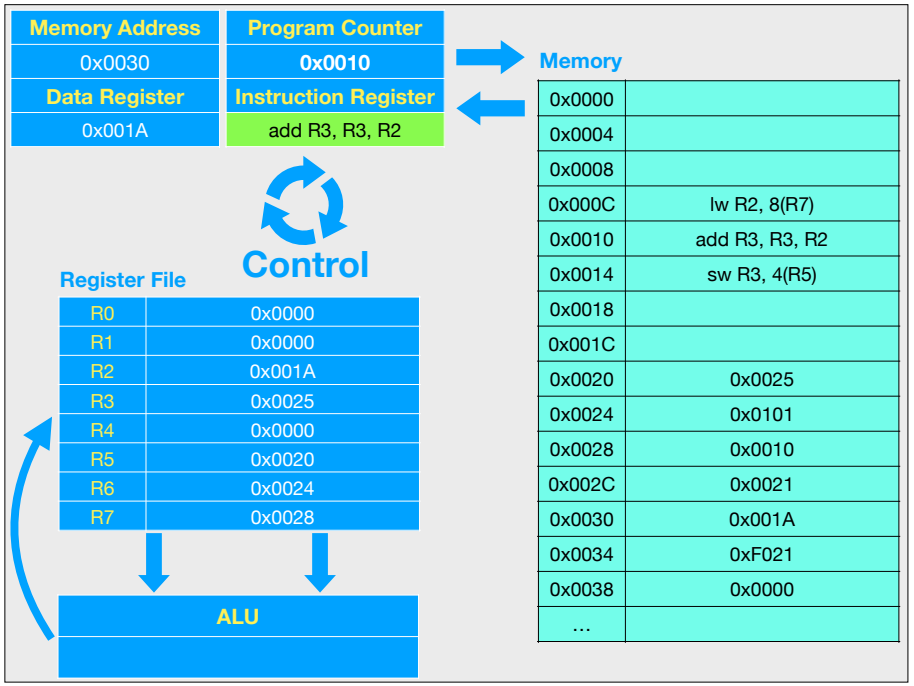

Memory Address
0x0030
Program Counter
0x000C
Data Register
Instruction Register
lw R2, 8(R7)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x0000
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

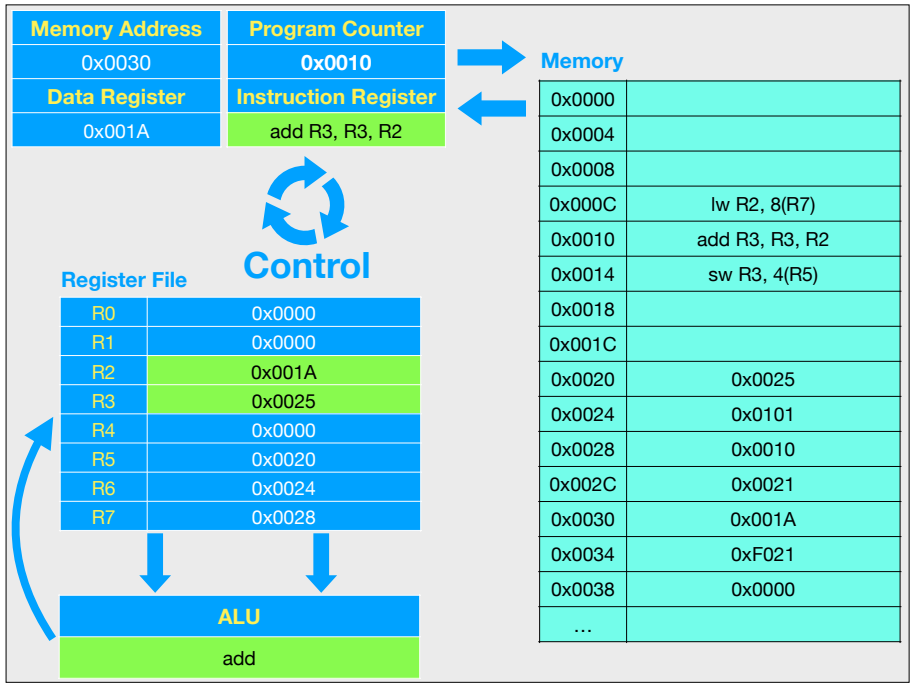

Memory Address
0x0030
Program Counter
0x000C
Data Register
Instruction Register
lw R2, 8(R7)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x0000
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

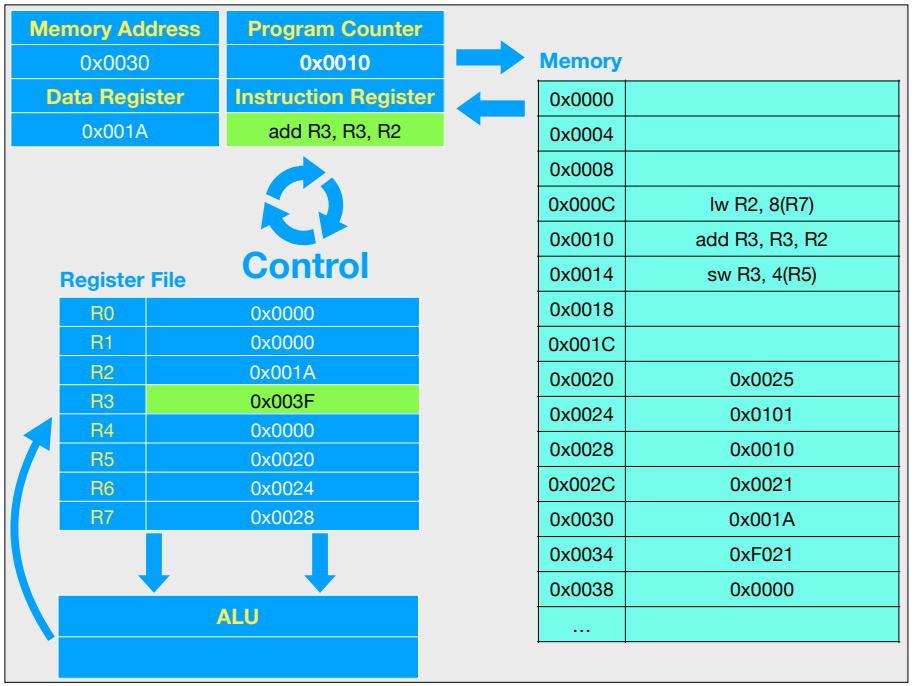

Memory Address
0x0030
Data Register
0x001A
Program Counter
0x000C
Instruction Register
lw R2, 8(R7)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x0000
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

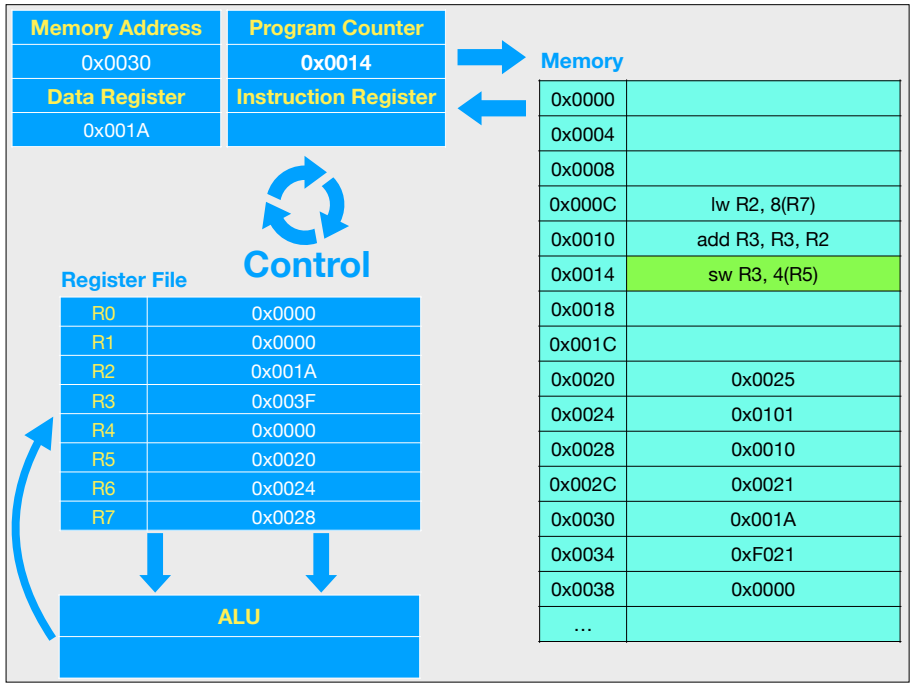

Memory Address
0x0030
Data Register
0x001A
Program Counter
0x000C
Instruction Register
lw R2, 8(R7)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

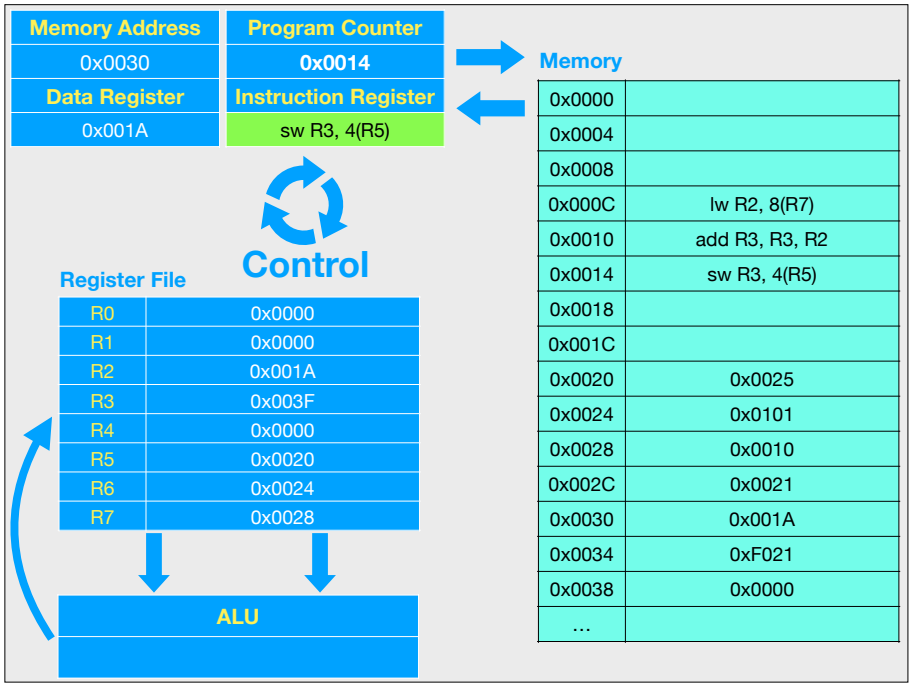

Memory Address
0x0030
Data Register
0x001A
Program Counter
0x0010
Instruction Register
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

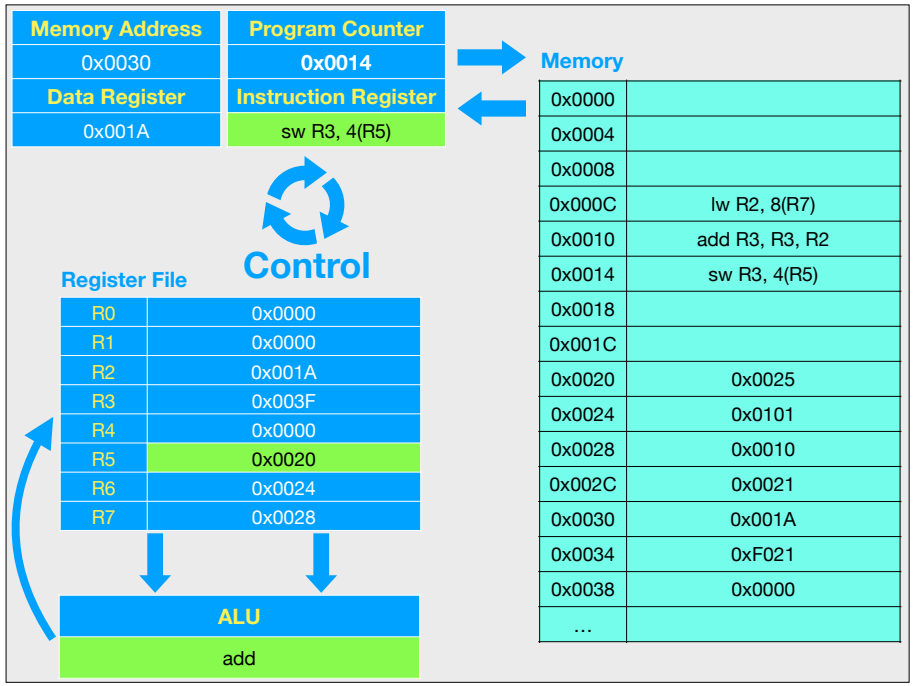

Memory Address
0x0030
Data Register
0x001A
Program Counter
0x0010
Instruction Register
add R3, R3, R2
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

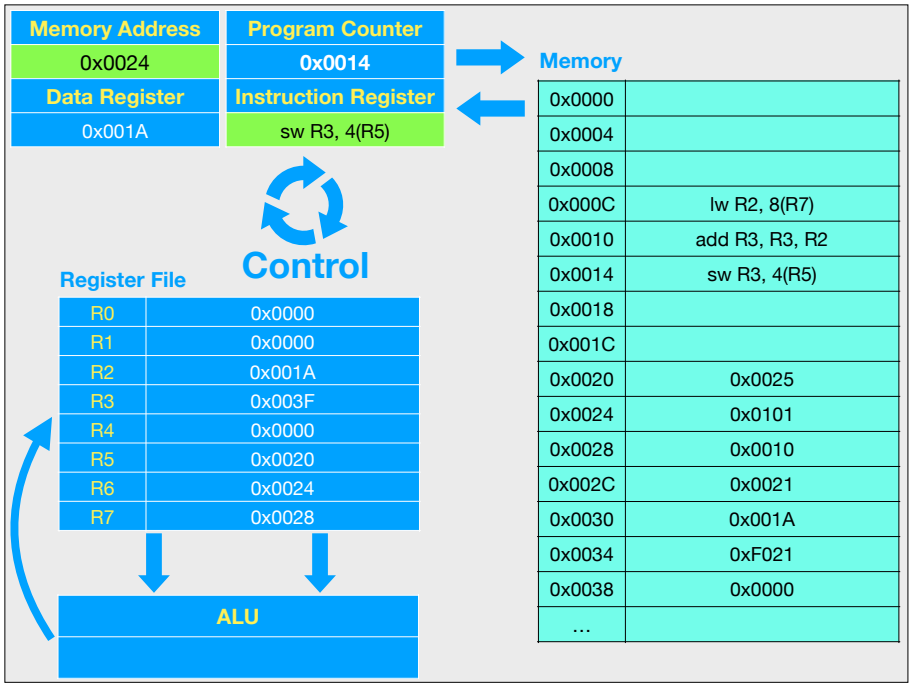

Memory Address
0x0030
Data Register
0x001A
Program Counter
0x0010
Instruction Register
add R3, R3, R2
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x0025
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU
add

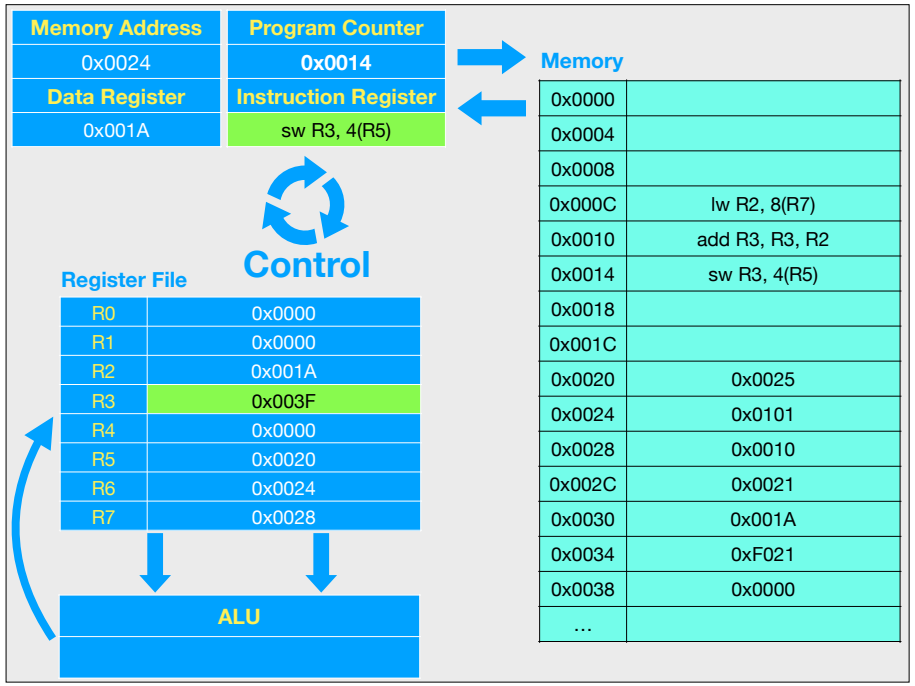

Memory Address
0x0030
Data Register
0x001A
Program Counter
0x0010
Instruction Register
add R3, R3, R2
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x003F
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

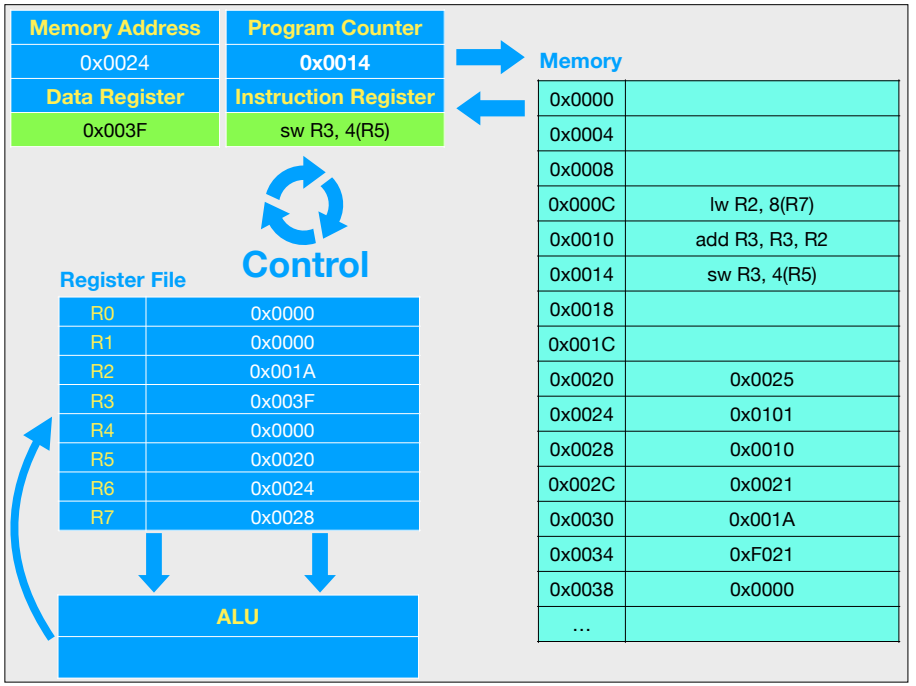

Memory Address
0x0030
Data Register
0x001A
Program Counter
0x0014
Instruction Register
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x003F
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU

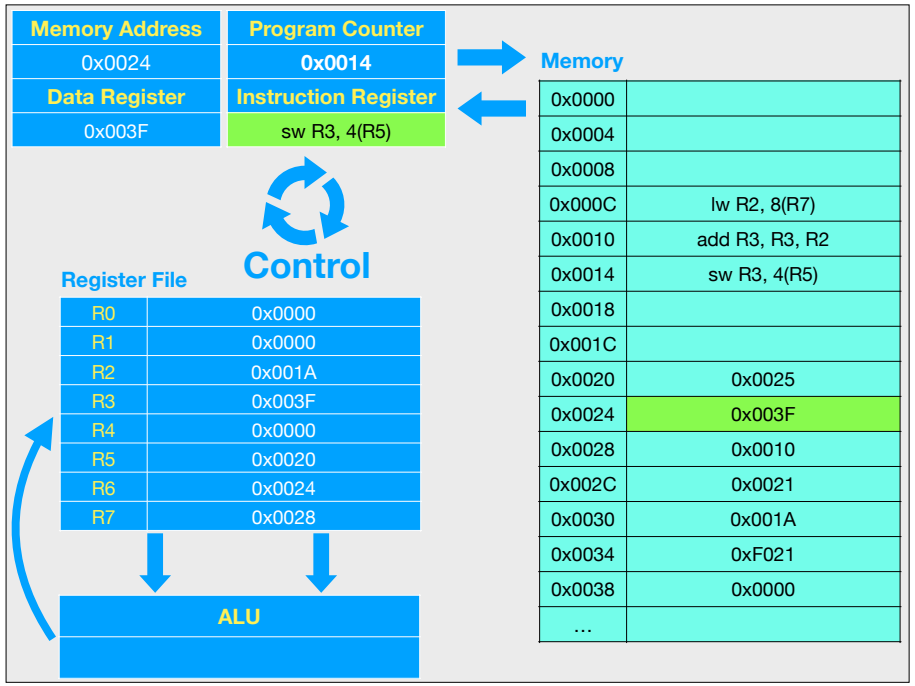

Memory Address
0x0030
Data Register
0x001A
Program Counter
0x0014
Instruction Register
sw R3, 4(R5)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x003F
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU


Memory Address
0x0030
Data Register
0x001A
Program Counter
0x0014
Instruction Register
sw R3, 4(R5)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x003F
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU
add


Memory Address
0x0024
Data Register
0x001A
Program Counter
0x0014
Instruction Register
sw R3, 4(R5)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x003F
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU


Memory Address
0x0024
Data Register
0x001A
Program Counter
0x0014
Instruction Register
sw R3, 4(R5)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x003F
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU


Memory Address
0x0024
Data Register
0x003F
Program Counter
0x0014
Instruction Register
sw R3, 4(R5)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x0101
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x003F
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU


Memory Address
0x0024
Data Register
0x003F
Program Counter
0x0014
Instruction Register
sw R3, 4(R5)
Memory
0x0000
0x0004
0x0008
0x000C lw R2, 8(R7)
0x0010 add R3, R3, R2
0x0014 sw R3, 4(R5)
0x0018
0x001C
0x0020 0x0025
0x0024 0x003F
0x0028 0x0010
0x002C 0x0021
0x0030 0x001A
0x0034 0xF021
0x0038 0x0000
...
Control
Register File
R0 0x0000
R1 0x0000
R2 0x001A
R3 0x003F
R4 0x0000
R5 0x0020
R6 0x0024
R7 0x0028
ALU