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Assignment 4 - XM23P Branch Instructions

This assignment aims to bring branching instructions to the emulator. This will allow for more control in changing flow of control of programs.

Testing

The following tests were implemented:

- Test 33: Branch True
- Test 34: Branch False
- Test 35: Bubble
- Test 36: Link Branch
- Test 37: NOOP Branch

Each test may be run from a powershell terminal with the following command:

```
Get-Content '.\Path\To\Input\File' | '.\Path\To\Executable'
```

Test 33: Branch True

Purpose

Ensure the branch instruction correctly branches when the condition is met.

Configuration

.\tests\Execute_Tests\Input_Files\Test33.in

1. Test33_Branch_True.xme was loaded into the emulator.
2. b 80 was entered to set a breakpoint at address #0080.
3. d was entered to enable debug mode.
4. g was entered to run the program.
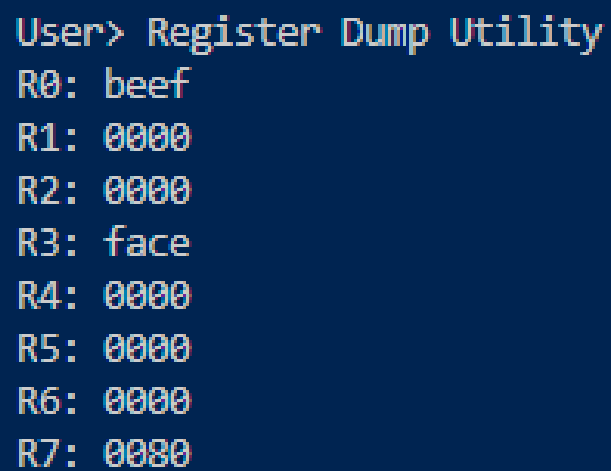5. r was entered to view the register contents.

Expected Results

R1, R2 should not contain #BEEF.
R3 should contain #FACE

Results

The register contents correctly matched:

```
User> Register Dump Utility
R0: beef
R1: 0000
R2: 0000
R3: face
R4: 0000
R5: 0000
R6: 0000
R7: 0080
```

Pass/Fail

Pass.

Test 34: Branch False

Purpose

Ensure the branch instruction correctly skips the branch when the condition is not met.

Configuration

.\tests\Execute_Tests\Input_Files\Test34.in

1. Test34_Branch_False.xme was loaded into the emulator.
2. b 110 was entered to set a breakpoint at address #0110.
3. d was entered to enable debug mode.
4. g was entered to run the program.
5. r was entered to view the register contents.

Expected Results
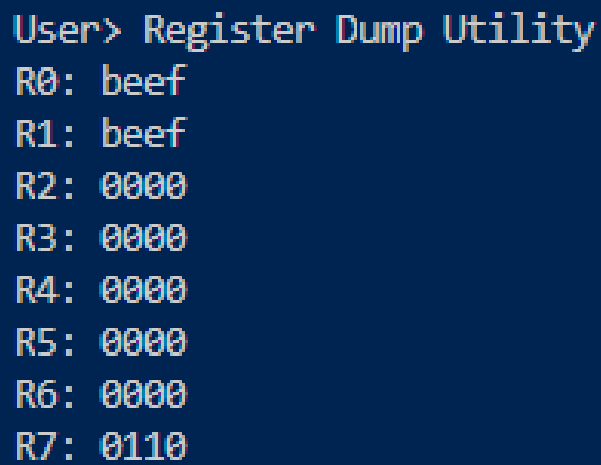
Only R0 and R1 should contain #BEEF.
R3 Should not contain #FACE.

Results

The register contents correctly matched:

```
User> Register Dump Utility
R0: beef
R1: beef
R2: 0000
R3: 0000
R4: 0000
R5: 0000
R6: 0000
R7: 0110
```

Pass/Fail

Pass.

Test 35: Bubble

Purpose

Verify the branch instruction correctly adds a bubble when a branch is taken, and does not add a bubble when the branch is not taken.

Configuration

.\tests\Execute_Tests\Input_Files\Test35.in

1. Test35_Bubble.xme was loaded into the emulator.
2. b 112 was entered to set a breakpoint at address #0112.
3. d was entered to enable debug mode.
4. g was entered to run the program.

Expected Results

A bubble should not be inserted when the condition of the first branch is not met at #0102.

A bubble should be inserted when the condition of the second branch is met at #0106.

Results

The pipeline bubbled as expected:

```
User> Run Utility
Clock          PC            Instruction    Fetch          Decode          Execute
0000           0100          0000           F0: 0100       D0: 0000                          CVNZ: 0000
Branching + 0 from 00fe to 0100
0001           0100          4588           F1: 4588                       E0: 0000          CVNZ: 0000
0002           0102          4588           F0: 0102       D0: 4588                          CVNZ: 0000
0003           0102          23b7           F1: 23b7                       E0: 4588          CVNZ: 0010
0004           0104          23b7           F0: 0104       D0: 23b7                          CVNZ: 0010
0005           0104          4580           F1: 4580                       E0: 23b7          CVNZ: 0010
0006           0106          4580           F0: 0106       D0: 4580                          CVNZ: 0010
0007           0106          2004           F1: 2004                       E0: 4580          CVNZ: 0001
0008           0108          2004           F0: 0108       D0: 2004                          CVNZ: 0001
Branching + 8 from 0106 to 0110
0009           010e          0000           F1: 0000                       E0: 2004          CVNZ: 0001
Bubblin'...
0010           0110          0000           F0: 0110       D0: 0000                          CVNZ: 0001
Branching + 0 from 010e to 0110
0011           0110          4c00           F1: 4c00                       E0: 0000          CVNZ: 0001
```

Pass/Fail

Pass.

Test 36: Link Branch

Purpose

Ensure the Link Register receives the correct address when a branch with link instruction is executed.

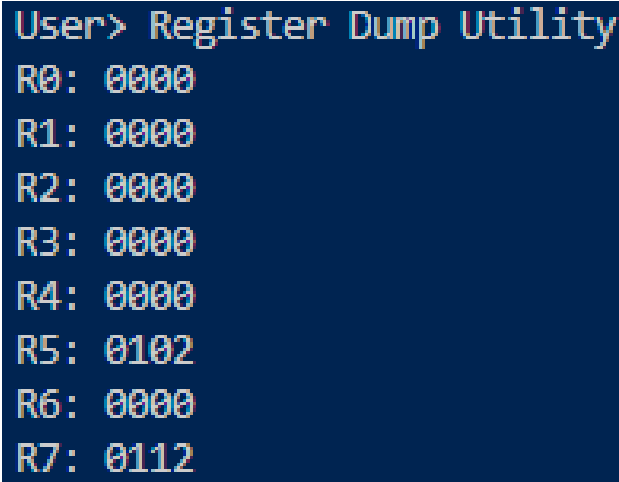#### Configuration

.\tests\Execute_Tests\Input_Files\Test36.in

1. Test36_Link_Branch.xme was loaded into the emulator.
2. b 112 was entered to set a breakpoint at address #0112.
3. d was entered to enable debug mode.
4. g was entered to run the program.
5. r was entered to view the register contents.

Expected Results

The Link Register R5 should contain #0102

Results

The register contents correctly matched:

```
User> Register Dump Utility
R0: 0000
R1: 0000
R2: 0000
R3: 0000
R4: 0000
R5: 0102
R6: 0000
R7: 0112
```

Pass/Fail

Pass.

Test 37: NOOP Branch

Purpose

Ensure a bubble is not inserted when a branch would not result in out of order execution.

Configuration

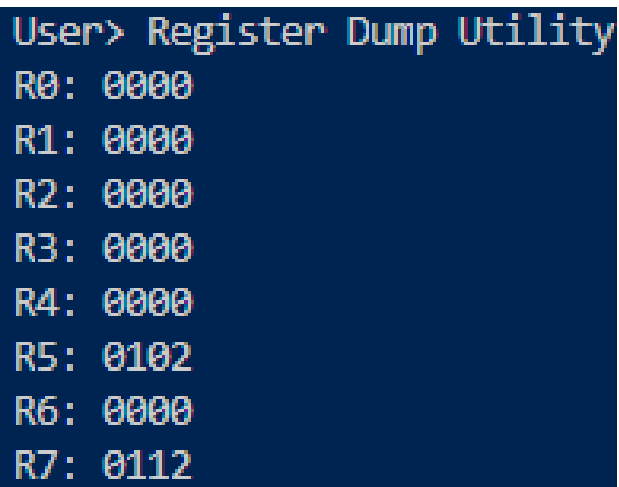.\tests\Execute_Tests\Input_Files\Test37.in

1. Test37_NOOP_Branch.xme was loaded into the emulator.
2. b 110 was entered to set a breakpoint at address #0110.
3. d was entered to enable debug mode.
4. g was entered to run the program.

Expected Results

No bubbles should be inserted.

Results

No bubbles were inserted:

```
User> Register Dump Utility
R0: 0000
R1: 0000
R2: 0000
R3: 0000
R4: 0000
R5: 0102
R6: 0000
R7: 0112
```

Pass/Fail

Pass.