

Computer Architecture HW #3

Due: Friday, Sept. 18 (5 PM in ITT 305 mailbox or under my office door, ITT 313)

1. Consider the following selection sort algorithm that sorts an array numbers:

```
SelectionSort(int length; int numbers[ ])
  int firstUnsortedIndex, testIndex, smallestIndex, temp
  for firstUnsortedIndex = 0 to (length-2) do
    smallestIndex = firstUnsortedIndex

    for testIndex = firstUnsortedIndex + 1 to length - 1 do
      if numbers[ testIndex ] < numbers[ smallestIndex ] then
        smallestIndex = testIndex
      end if
    end for

    temp = numbers[ firstUnsortedIndex ]
    numbers [ firstUnsortedIndex ] = numbers [ smallestIndex ]
    numbers [ smallestIndex ] = temp
  end for
end SelectionSort
```

- Where in the code would unconditional branches be used and where would conditional branches be used?
- If the compiler could predict by opcode for the conditional branches (i.e., select whether to use machine language statements like: "BRANCH_LE_PREDICT_NOT_TAKEN" or "BRANCH_LE_PREDICT_TAKEN"), then which conditional branches would be "PREDICT_NOT_TAKEN" and which would be "PREDICT_TAKEN"?
- Assumptions:
 - length = 100 and the numbers are initially in **ascending** order before the selection sort algorithm is called
 - the six-stage pipeline of the text
 - the outcome of conditional branches is known at the end of the EI stage
 - target addresses of all branches is known at the end of the CO stage
 - ignore any data hazards

Under the above assumptions, answer the following questions:

- If static predict-never-taken is used by the hardware, then what will be the total branch penalty (# cycles wasted) for the algorithm? (Here assume NO branch-history table) For partial credit, explain your answer.
- If a branch-history table with one history bit per entry is used, then what will be the total branch penalty (# cycles wasted) for the algorithm? (Assume predict-not taken is used if there is no match in the branch-history table) For partial credit, explain your answer.
- If a branch-history table with two history bits per entry is used as in Figure 11.16, then what will be the total branch penalty (# cycles wasted) for the algorithm? (Assume predict-not taken is used if there is no match in the branch-history table) For partial credit, explain your answer.