the modification. For example, consider the *scratch* instruction used to read from Scratchpad memory. Indirect reference allows a programmer to modify any of several fields:

- The microengine associated with the memory reference
- The first transfer register in a block that will receive the result
- A count of words of memory to transfer
- The context number of the hardware context executing the instruction (i.e., the thread to signal upon completion)
- The mask that specifies a set of signals

In cases where the count of words to transfer depends on the data, a constant value will not suffice — the count must be computed at runtime. Indirect reference allows the count to be extracted from the previous ALU instruction. To do so, the programmer must specify a value for the count and a value that specifies which field of the instruction to modify. The two values are encoded into a thirty-two bit binary value. For example, bit twenty-five corresponds to the count field; when bit twenty-five is set, the new count is specified in bits twenty-one through twent-three. Consider the two instructions below:

```
alu_shf [ --, --, b, 0x13, << 21 ]
scratch [ read, $reg0, addr1, addr2, 0 ], indirect_ref
```

The ALU instruction shifts 0x13 left twent-one bits, which places *0x1* in bit twenty-five (i.e., turns on bit twenty-five), and places *0x3* in bits twenty-one through twenty-three. The destination is coded as two minus signs, which specifies no destination (i.e., the value is computed, but not stored). Although the *scratch* instruction is coded with a count of zero, the indirect reference token causes the value from the previous instruction to be used as a modifier. Thus, the *count* field in the *scratch* instruction will be replaced by the integer three, which means that four words will be read from Scratchpad memory†.

23.15 External Transfers

All external data transfers (e.g., to or from external memory) use *transfer registers*. To perform an external transfer, the programmer must:

†A value of N in the *count* field means that $N + 1$ words of memory are transferred (i.e., the count is one less than the transfer size).