

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 twenty-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 twenty-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<sup>†</sup>.

## 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:

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<sup>†</sup>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).