

ANSWER

The lack of a 33rd bit means that when overflow occurs, the sign bit is set with the *value* of the result instead of the proper sign of the result. Since we need just one extra bit, only the sign bit can be wrong. Hence, overflow occurs when adding two positive numbers and the sum is negative, or vice versa. This means a carry out occurred into the sign bit.

Overflow occurs in subtraction when we subtract a negative number from a positive number and get a negative result, or when we subtract a positive number from a negative number and get a positive result. This means a borrow occurred from the sign bit. Figure 3.2 shows the combination of operations, operands, and results that indicate an overflow.

We have just seen how to detect overflow for two’s complement numbers in a computer. What about overflow with unsigned integers? Unsigned integers are commonly used for memory addresses where overflows are ignored.

The computer designer must therefore provide a way to ignore overflow in some cases and to recognize it in others. The MIPS solution is to have two kinds of arithmetic instructions to recognize the two choices:

- Add (add), add immediate (addi), and subtract (sub) cause exceptions on overflow.
- Add unsigned (addu), add immediate unsigned (addiu), and subtract unsigned (subu) do *not* cause exceptions on overflow.

Because C ignores overflows, the MIPS C compilers will always generate the unsigned versions of the arithmetic instructions addu, addiu, and subu, no matter what the type of the variables. The MIPS Fortran compilers, however, pick the appropriate arithmetic instructions, depending on the type of the operands.

Operation	Operand A	Operand B	Result indicating overflow
$A + B$	$\geq 0$	$\geq 0$	$< 0$
$A + B$	$< 0$	$< 0$	$\geq 0$
$A - B$	$\geq 0$	$< 0$	$< 0$
$A - B$	$< 0$	$\geq 0$	$\geq 0$

**FIGURE 3.2** Overflow conditions for addition and subtraction.

**Arithmetic Logic Unit (ALU)** Hardware that performs addition, subtraction, and usually logical operations such as AND and OR.

❏ **Appendix C** describes the hardware that performs addition and subtraction, which is called an **Arithmetic Logic Unit** or **ALU**.