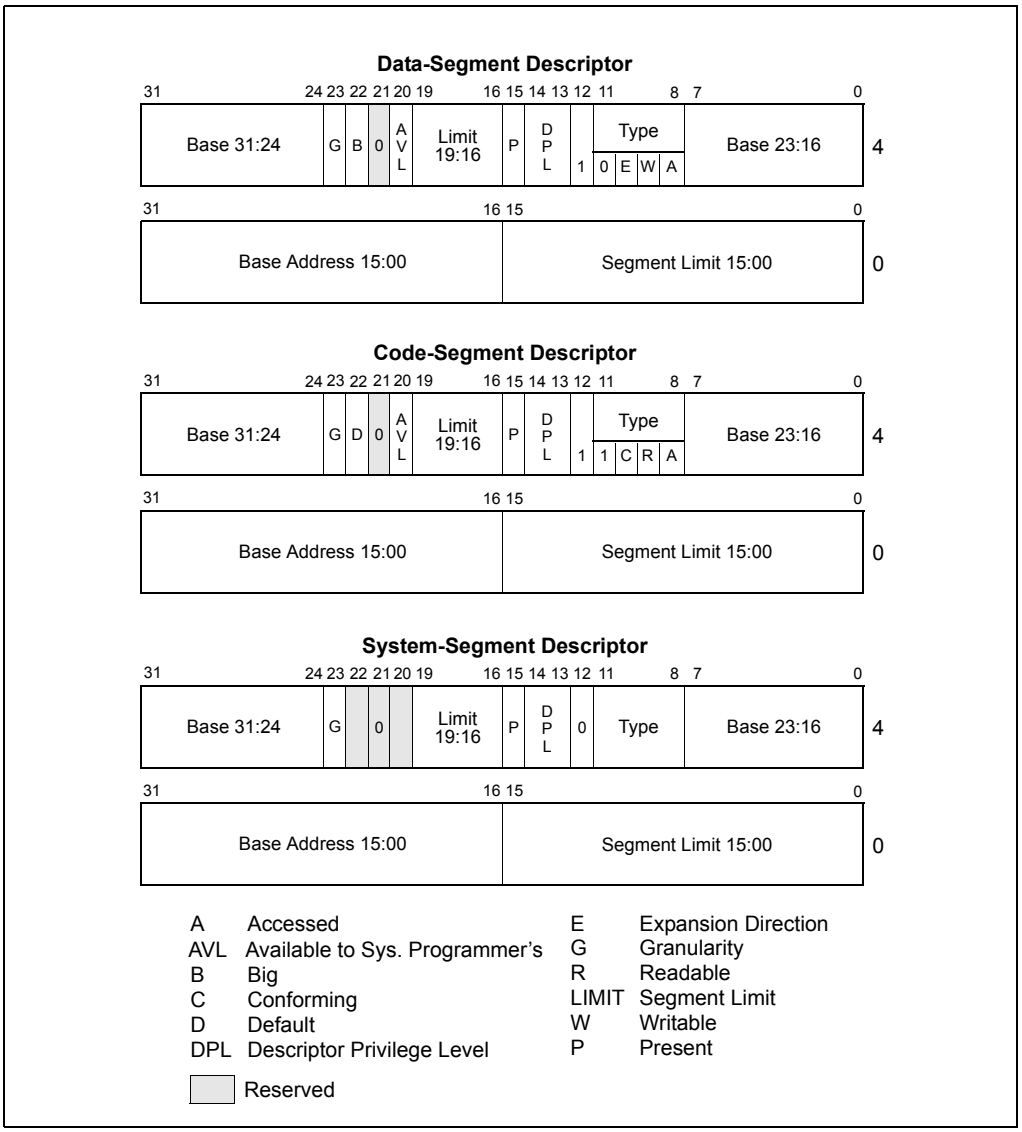

Figure 5-1. Descriptor Fields Used for Protection

Many different styles of protection schemes can be implemented with these fields and flags. When the operating system creates a descriptor, it places values in these fields and flags in keeping with the particular protection style chosen for an operating system or executive. Application program do not generally access or modify these fields and flags.

The following sections describe how the processor uses these fields and flags to perform the various categories of checks described in the introduction to this chapter.

5.2.1 Code Segment Descriptor in 64-bit Mode

Code segments continue to exist in 64-bit mode even though, for address calculations, the segment base is treated as zero. Some code-segment (CS) descriptor content (the base address and limit fields) is ignored; the remaining fields function normally (except for the readable bit in the type field).

Code segment descriptors and selectors are needed in IA-32e mode to establish the processor's operating mode and execution privilege-level. The usage is as follows:

- IA-32e mode uses a previously unused bit in the CS descriptor. Bit 53 is defined as the 64-bit (L) flag and is used to select between 64-bit mode and compatibility mode when IA-32e mode is active (IA32_EFER.LMA = 1). See Figure 5-2.
  - — If CS.L = 0 and IA-32e mode is active, the processor is running in compatibility mode. In this case, CS.D selects the default size for data and addresses. If CS.D = 0, the default data and address size is 16 bits. If CS.D = 1, the default data and address size is 32 bits.
  - — If CS.L = 1 and IA-32e mode is active, the only valid setting is CS.D = 0. This setting indicates a default operand size of 32 bits and a default address size of 64 bits. The CS.L = 1 and CS.D = 1 bit combination is reserved for future use and a #GP fault will be generated on an attempt to use a code segment with these bits set in IA-32e mode.
- In IA-32e mode, the CS descriptor's DPL is used for execution privilege checks (as in legacy 32-bit mode).

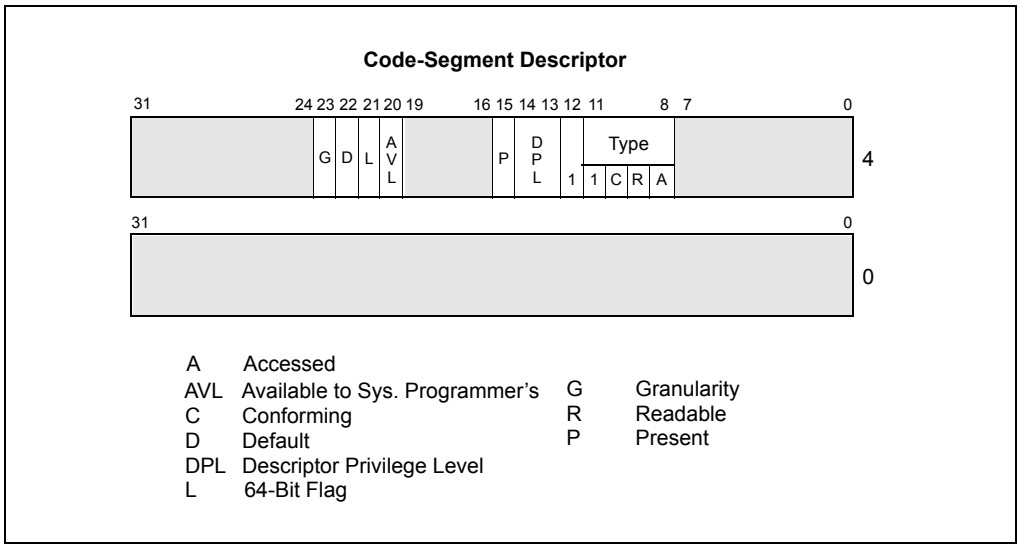

Figure 5-2. Descriptor Fields with Flags used in IA-32e Mode

5.3 LIMIT CHECKING

The limit field of a segment descriptor prevents programs or procedures from addressing memory locations outside the segment. The effective value of the limit depends on the setting of the G (granularity) flag (see Figure 5-1). For data segments, the limit also depends on the E (expansion direction) flag and the B (default stack pointer size and/or upper bound) flag. The E flag is one of the bits in the type field when the segment descriptor is for a data-segment type.

When the G flag is clear (byte granularity), the effective limit is the value of the 20-bit limit field in the segment descriptor. Here, the limit ranges from 0 to FFFFFH (1 MByte). When the G flag is set (4-KByte page granularity), the processor scales the value in the limit field by a factor of 2^{12} (4 KBytes). In this case, the effective limit ranges from FFFH (4 KBytes) to FFFFFFFFH (4 GBytes). Note that when scaling is used (G flag is set), the lower 12 bits of a segment offset (address) are not checked against the limit; for example, note that if the segment limit is 0, offsets 0 through FFFH are still valid.

For all types of segments except expand-down data segments, the effective limit is the last address that is allowed to be accessed in the segment, which is one less than the size, in bytes, of the segment. The processor causes a general-protection exception (or, if the segment is SS, a stack-fault exception) any time an attempt is made to access the following addresses in a segment:

- A byte at an offset greater than the effective limit
- A word at an offset greater than the (effective-limit – 1)