Predicting software complexity can save millions in maintenance costs, but while current measures can be used to some degree, most are not sufficiently sensitive or comprehensive.

Applying Software Complexity Metrics to Program Maintenance

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Over the past several years, computer scientists have devoted a great deal of effort to measuring computer program "complexity," since many large software systems can be used for 10, 15, or even 20 years. A large part of that time involves maintenance activities, which include all changes made to a piece of software after it has been delivered to and accepted by the final user. Consequently, maintenance is most affected by program complexity.

Recent estimates suggest that about 40 to 70 percent of annual software expenditures involve maintenance of existing systems. Clearly, if complexities could somehow be identified, then programmers could adjust maintenance procedures accordingly. What is needed is some method of pinpointing the characteristics of a computer program that are difficult to maintain and measuring the degree of their presence (or lack of it). Such a method could be used in preparing "quality specifications" for programs that are to be written; checking specification compliance of programs after they have been written, but before they are delivered; making proper design trade-offs between development and maintenance costs; and selecting a particular type of software.

Software complexity

The degree to which characteristics that impede software maintenance are present is called software *maintainability* and is driven primarily by *software complexity*, the measure of how difficult the program is to comprehend and work with. Maintenance characteristics that are affected by complexity include software understandability, software modifiability, and software testability.

Various approaches may be taken in measuring complexity characteristics, such as Baird and Noma's[1] approach, in which scales of measurement are divided into the following four types:

(1) *Nominal scales.* The measure classifies the items. For example, programs are grouped into classifications of "not difficult to understand," "moderately difficult to understand," "difficult to understand," and "very difficult to understand."

(2) *Ordinal scales.* The measure actually ranks individual items. For example, we would say not only that program *A*, program *B*, and program *C* are all "moderately difficult to understand," but also that program *B* was more difficult to understand than program *C*, and program *A* was more difficult to understand than program *B*.

(3) *Interval scales.* The measure not only ranks items in relation to each other but also tells how far apart they are. For example, we would say not only that program *A* was more difficult than program *B* but also that program *A* was 10 "units of difficulty" more difficult to understand than program *B*.

(4) *Ratio scales.* The measure not only ranks the items and determines how far apart they are from each other but also determines how far the measures lie from a total lack of the characteristic being measured. This allows multiplication and division to be used on the resulting measures, so we can obtain measures that indicate that program *A* is twice as difficult to understand as program *B*. This property is unique to the ratio scale.

The most flexible type of measurement seems to be the ratio scale, but we would be hard put to find a degree of impeding characteristics that even approaches zero complexity, so this scale is not really the most effective. On the other hand, an ordinal scale would be feasible, and in some cases, even an interval scale could be developed, but a major problem with interval scales is determining the "unit of difficulty" and its meaning.

We believe the ordinal scale to be the best choice for examining complexity metrics, and all measures discussed in this article are in that framework.

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