Expanding the Role of Tools in a Literate Programming Environment

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Abstract

The tools in a literate programming environment need to accept additional responsibility to support the programmer's communication with other programmers.

1. The Expanded Role of Programmers

Traditionally, the programmer's role has been to understand a problem and encode that knowledge in a program a computer can execute. The problem with this approach is that focusing on the computer as the consumer of programs leads to programs that are difficult for other programmers to understand. Maintenance and reusability have emerged as two of the hardest problems in software engineering, and solutions to both rely on the other programmers being able to understand a program.

Knuth's Literate Programming [Knut84] [Bent86a] [Bent86b] is one approach for shifting the programmer's focus to include other humans as code consumers. A literate program is a literary entity, written to be read from beginning to end, and taking on the character of a book or essay. Literate programming expands the role of the programmer to include the responsibility for organizing a program in such a way that a reader is led naturally to an understanding of the decisions that shaped the code.

Knuth has created a language, Web, for writing literate programs. A Web program is a mixture of Pascal, TEX, and Web commands. In addition to cross referencing, Web includes a macro language, used to avoid Pascal's problems with forward reference and to allow the programmer to break up Pascal functions into explainable pieces. To create a literate program using Web, the programmer must understand Pascal, TEX, and Web, and must be prepared to deal with errors in any of the languages.

We have been experimenting with a literate programming environment in Smalltalk-80 [Beck86]. We first built a simple document preparation system, the Literate Program Browser, which allowed a user to integrate text from various sources in a document. Initially the sources were code from the Smalltalk system and explanatory text from the programmer. In this way, a programmer could annotate the methods in a Smalltalk program to provide a level of documentation greater than that of embedded comments.

2. Expanding the Role of Tools

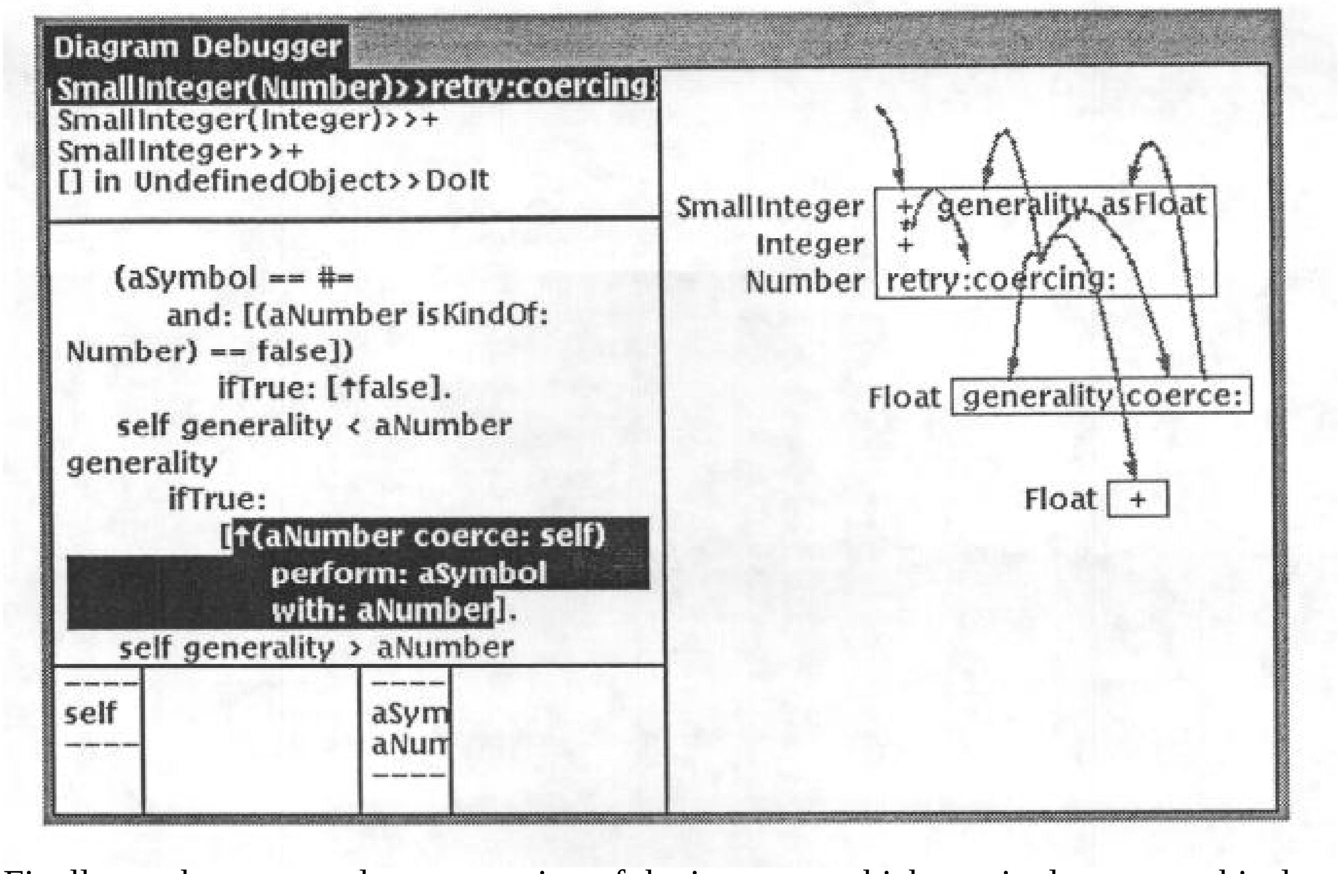
The Smalltalk environment includes many tools to help the programmer understand a program. The browser conveniently organizes the source code of the Smalltalk system, the inspector lets the user trace the pointer structure of objects, and the debugger makes visible the dynamic binding of messages to methods during the execution of a Smalltalk program. In the hands of both novice and expert users these tools help programmers understand a problem and create an object-oriented solution. As we have seen above, however, understanding a problem is only half of the task of the programmer.

Just as the programmer in a literate programming environment takes the additional responsibility of communicating to other programmers, the tools in a literate programming environment (or any other programming environment focused on communicating to both computers and humans) must accept additional responsibility. In particular, they must be prepared to make the information they manipulate in a form suitable for inclusion in a document.

In our system, we capture the dynamic behavior of a running program by initiating an asynchronous interrupt from a function key and indicating the region of the screen to be saved. This bitmap can then be pasted into a literate program. In this way the input/output nature of an interactive program can easily be documented in a document. To describe a menu that pops up, the programmer pops up the menu and captures the physical appearance from the screen.

We modified the browser so that it also offers its contents in a form suitable for inclusion in a document. We added menu items to copy class and method definitions into a literate program. Importantly, these definitions are not saved as text, but as pointers into the Smalltalk source code system, so when a document is printed, the definitions print with their current value, not just their value on creation.

Similarly, we have extended the debugger to make program traces available for inclusion in a document (see below). An additional pane in the debugger lets the programmer selectively include message sends in a diagrammatic representation we have created specifically for object-oriented programs [Cunn86]. These diagrams can be copied from the debugger and pasted into a literate program.

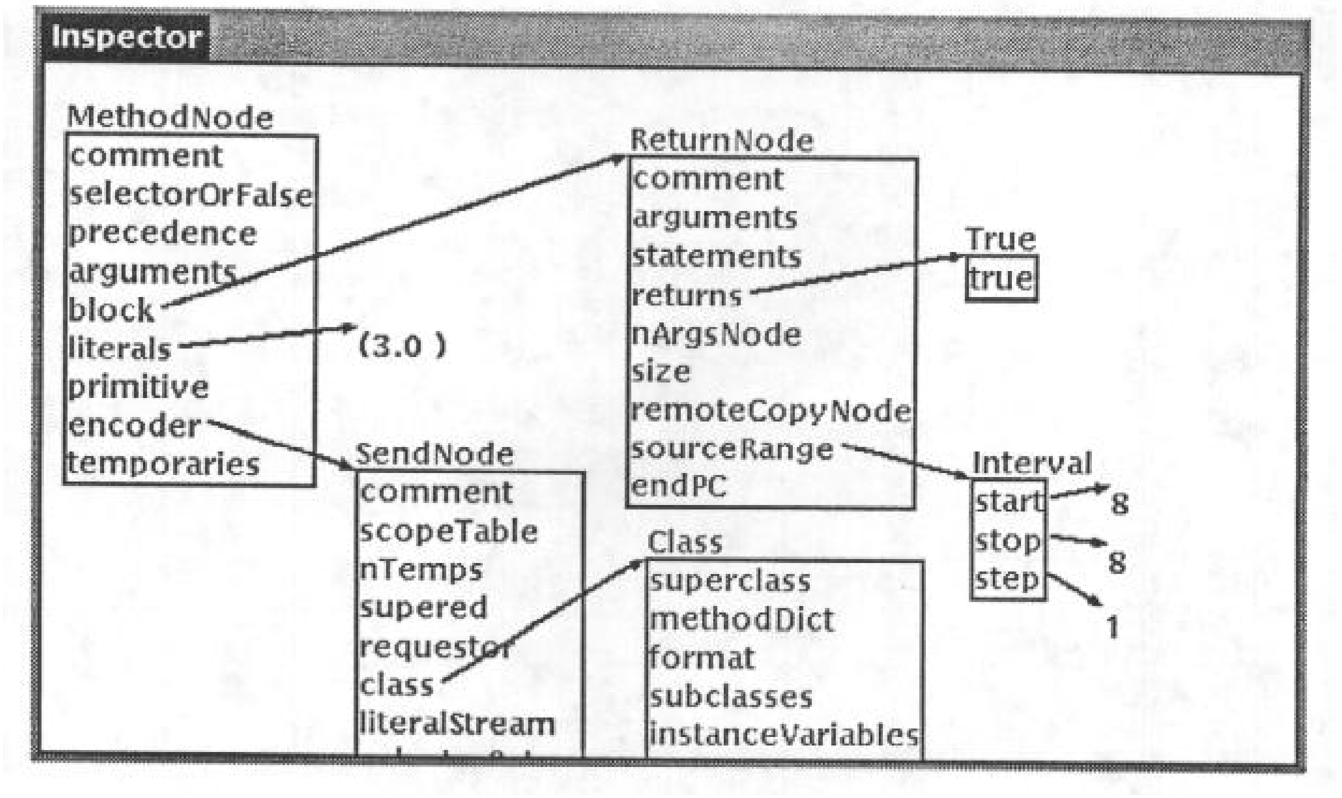


```
SmallInteger(Number)>>retry:coercing:
SmallInteger(Integer)>>+
SmallInteger>>+
[] in UndefinedObject>>DoIt
```

```
    (aSymbol == #=
        and: [(aNumber isKindOf:
Number) == false])
            ifTrue: [↑false].
    self generality < aNumber
generality
        ifTrue:
            [↑(aNumber coerce: self)
                perform: aSymbol
                with: aNumber].
    self generality > aNumber
```

```
----        ----
self        aSym
----        aNum
            ----
```

Finally, we have created a new version of the inspector which manipulates a graphical representation of objects and pointers (see below). An object displays as a box containing the names of its instance variables and labeled by the object's class. Pointing to an instance variable in an object causes the contents of that variable (an object) to be added to the diagram, with a link from the variable to the object. Objects are uniquely represented in the diagram, so if an object is referenced several times, all the links point to the same object.



3. Implementation

We believe the Smalltalk-80 programming environment has aided us immensely in the creation of a fully literate programming environment. Rather than having to write all of our tools from scratch we were able to refine existing tools, making it possible to rapidly experiment with different approaches. in addition, good Smalltalk code is typically in small (5-7 line) pieces, about the right size code fragment to include in a literate program, obviating the need for a macro language.

A tool we built that has helped us many times is a generic graphics editor It was designed to make creating graphical interfaces just as easy as creating textual interfaces, and it has made it possible for us to quickly create graphical representations of various data structures in the system. In addition, because the generic graphical objects accept the responsibility of transforming themselves into a form suitable for typesetting, all of the graphical representations we create inherit the ability to be included in documents.

Our strategy for printing is to use the MS macros for the troff typesetting package to produce text. We are working with Apple LaserWriter printers, so we turn all graphic objects into PostScript, which is embedded in the troff input postscript provides a powerful set of imaging primitives which create graphics at printer resolution, but it also manipulates bit-mapped images so a new graphical object can create a rough but adequate printed representation by copying an image from the screen.

4. Conclusion

The environment of a programmer who has accepted the responsibility of communicating with other programmers must support this activity. The tools in the environment must be prepared to create diagrammatic or textual representations of the information they manipulate suitable for inclusion in a document. As the programmer must be prepared to communicate with other programmers, so, too, must the tools.

References

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