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(54) **INTERPRETING FUNCTIONS UTILIZING A HYBRID OF VIRTUAL AND NATIVE MACHINE INSTRUCTIONS**

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(58) **Field of Search** 717/151, 159, 717/139, 148; 718/1

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,329,611 A 7/1994 Pechanek et al.
5,367,685 A 11/1994 Gosling
5,586,328 A 12/1996 Caron et al.
5,758,162 A 5/1998 Takayama et al.
5,768,593 A 6/1998 Walters et al.
5,845,298 A 12/1998 O'Conner et al.
5,898,850 A 4/1999 Dickol et al.
5,905,895 A 5/1999 Halter
5,925,123 A 7/1999 Tremblay et al.
5,953,736 A 9/1999 O'Conner et al.
5,995,754 A * 11/1999 Holzle et al. 717/158
6,038,394 A 3/2000 Layes

(Continued)

OTHER PUBLICATIONS

Proebsting, Todd A., "Optimizing an ANSI C Interpreter with Superoperators," pp. 322–332, Jan. 1995.
Hsieh, Cheng–Hsueh et al., "Java Bytecode to Native Code Translation: The caffeine prototype and preliminary results," pp. 90–97, Dec. 1996.
Lambright, H. Dan., "Java Bytecode Optimizations," pp. 206–210, Feb. 1997.
Pittan Thomas, "Two–level Hybrid Interpreter/Native Code Execution for combined space time program efficiency," ACM, pp. 150–152, Jun. 1987.
Kaufer, Stephen et al., "Saber–C, An Interpreter–based programming environment for the C language," USENIX, pp. 161–171, Jun. 1988.
Davidson, Jack W. et al., "Cint: A RISC Interpreter for the C programming language," ACM, pp. 189–198, Jun. 1987.

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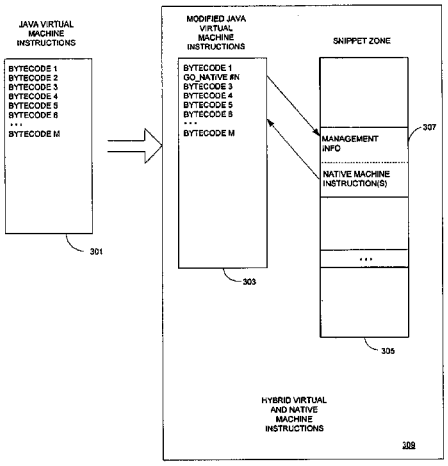
(57) **ABSTRACT**

Systems and methods for increasing the execution speed of virtual machine instructions for a function are provided. A portion of the virtual machine instructions of the function are compiled into native machine instructions so that the function includes both virtual and native machine instructions. Execution of the native machine instructions may be accomplished by overwriting a virtual machine instruction of the function with a virtual machine instruction that specifies execution of the native machine instructions. Additionally, the original virtual machine instruction may be stored so that the original virtual machine instructions can be regenerated.

14 Claims, 12 Drawing Sheets