



US006397242B1

(12) **United States Patent**
Devine et al.

(10) **Patent No.:** US 6,397,242 B1
(45) **Date of Patent:** May 28, 2002

(54) **VIRTUALIZATION SYSTEM INCLUDING A VIRTUAL MACHINE MONITOR FOR A COMPUTER WITH A SEGMENTED ARCHITECTURE**

5,761,477 A * 6/1998 Wahbe et al. 709/1
5,832,205 A 11/1998 Kelly et al.

OTHER PUBLICATIONS

(75) Inventors: **Scott W. Devine**, Palo Alto; **Edouard Bugnion**, Menlo Park; **Mendel Rosenblum**, Stanford, all of CA (US)

Goldberg, "Survey of Virtual Machine Research," Computer, Jun. 1974, pp. 34-45.
Ebciglu et al., "IBM Research Report—Daisy: Dynamic Compilation for 100% Architectural Compatibility", RC 20538, Aug. 5, 1996.

(73) Assignee: **VMWare, Inc.**, Palo Alto, CA (US)

Bugnion, "Disco: Running Commodity Operating Systems on Scalable Multiprocessors," ACM Trans. on Computer Systems, vol. 15, No. 4, Nov. 1997, pp. 412-447.

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

Bressoud, "Hypervisor-based Fault-tolerance," SIGOPS '95, Dec. 1995, pp. 1-11.

(21) Appl. No.: **09/179,137**

Rosenblum et al., "Using the SimOS Machine Simulator to Study Complex Computer Systems," ACM Trans. on Modeling and Computer Simulation, vol 7, No. 1, Jan. 1997, pp. 78-103.

(22) Filed: **Oct. 26, 1998**

Creasy, "The Origin of the VM/370 Time-Sharing System," IBM J. Res. Develop., vol. 25, No. 5, Sep. 1981.

Related U.S. Application Data

(60) Provisional application No. 60/085,685, filed on May 15, 1998.

Intel Architecture Software Developer's Manual, vol. 3, 1997.

(51) **Int. Cl.** **G06F 9/00**

* cited by examiner

(52) **U.S. Cl.** **709/1; 709/214; 709/321; 703/27; 710/23; 711/148; 711/153**

Primary Examiner—Majid Banankhah
(74) *Attorney, Agent, or Firm*—Jeffrey Slusher

(58) **Field of Search** **709/100, 1, 200, 709/224, 316, 320, 328, 330, 223; 717/131, 138, 140; 703/26, 27; 714/1, 2, 47**

(57) **ABSTRACT**

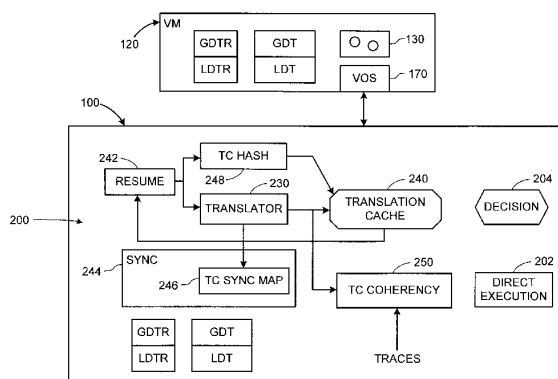
(56) **References Cited**

In a computer that has hardware processor, and a memory, the invention provides a virtual machine monitor (VMM) and a virtual machine (VM) that has at least one virtual processor and is operatively connected to the VMM for running a sequence of VM instructions, which are either directly executable or non-directly executable. The VMM includes both a binary translation sub-system and a direct execution sub-system, as well as a sub-system that determines if VM instructions must be executed using binary translation, or if they can be executed using direct execution. Shadow descriptor tables in the VMM, corresponding to VM descriptor tables, segment tracking and memory tracing are used as factors in the decision of which execution mode to activate. The invention is particularly well-adapted for virtualizing computers in which the hardware processor has an Intel x86 architecture.

U.S. PATENT DOCUMENTS

- 4,747,040 A 5/1988 Blanset et al.
- 4,787,031 A 11/1988 Karger et al.
- 4,792,895 A 12/1988 Tallman
- 4,926,322 A 5/1990 Stimac et al.
- 4,974,159 A 11/1990 Hargrove et al.
- 5,134,580 A 7/1992 Bertram et al.
- 5,167,023 A 11/1992 de Nicolas et al.
- 5,255,379 A 10/1993 Melo
- 5,307,504 A 4/1994 Robinson et al.
- 5,440,710 A 8/1995 Richter et al.
- 5,488,716 A 1/1996 Schneider et al.
- 5,522,075 A 5/1996 Robinson et al.
- 5,560,013 A * 9/1996 Scalzi et al. 717/138
- 5,652,869 A 7/1997 Herdeg et al.
- 5,652,872 A 7/1997 Richter et al.
- 5,721,922 A 2/1998 Dingwall

28 Claims, 6 Drawing Sheets



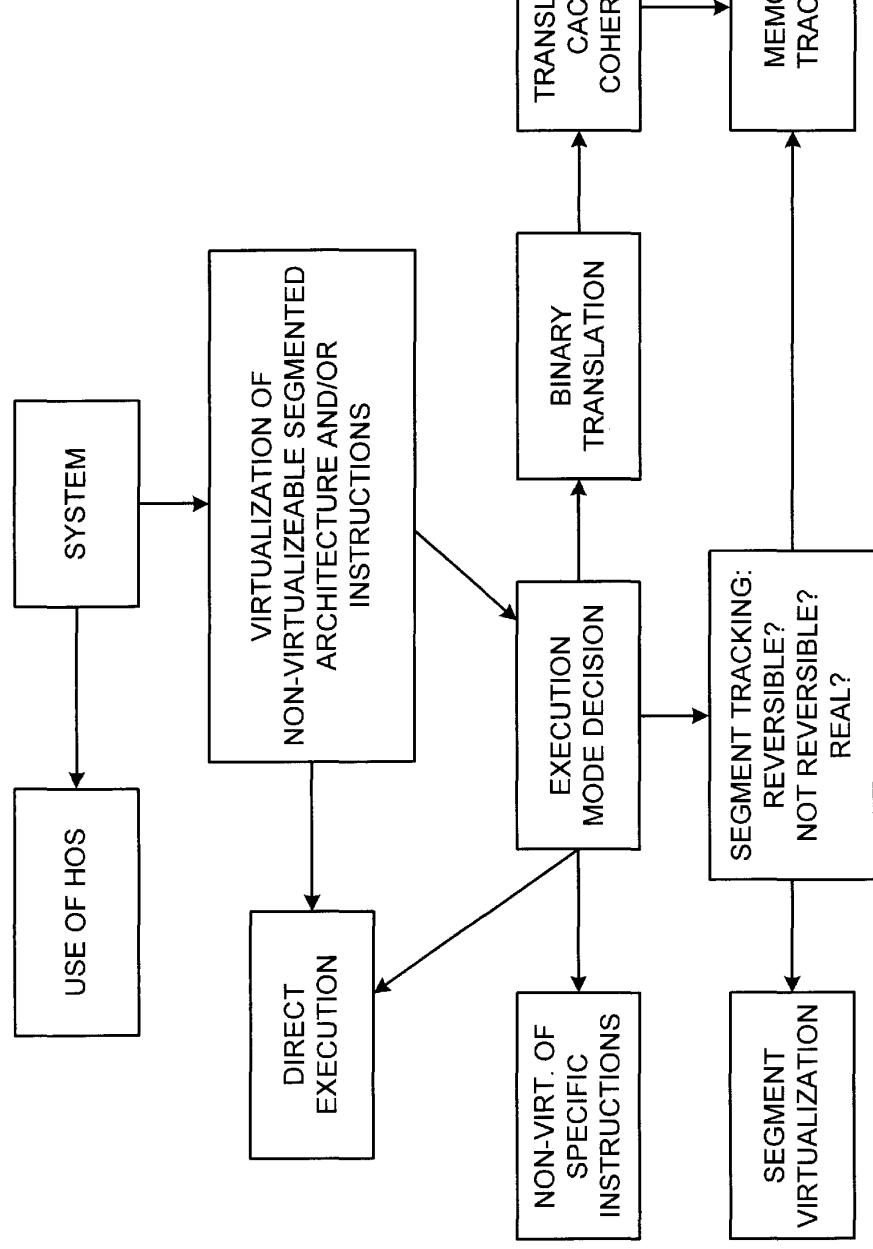


FIG. 1

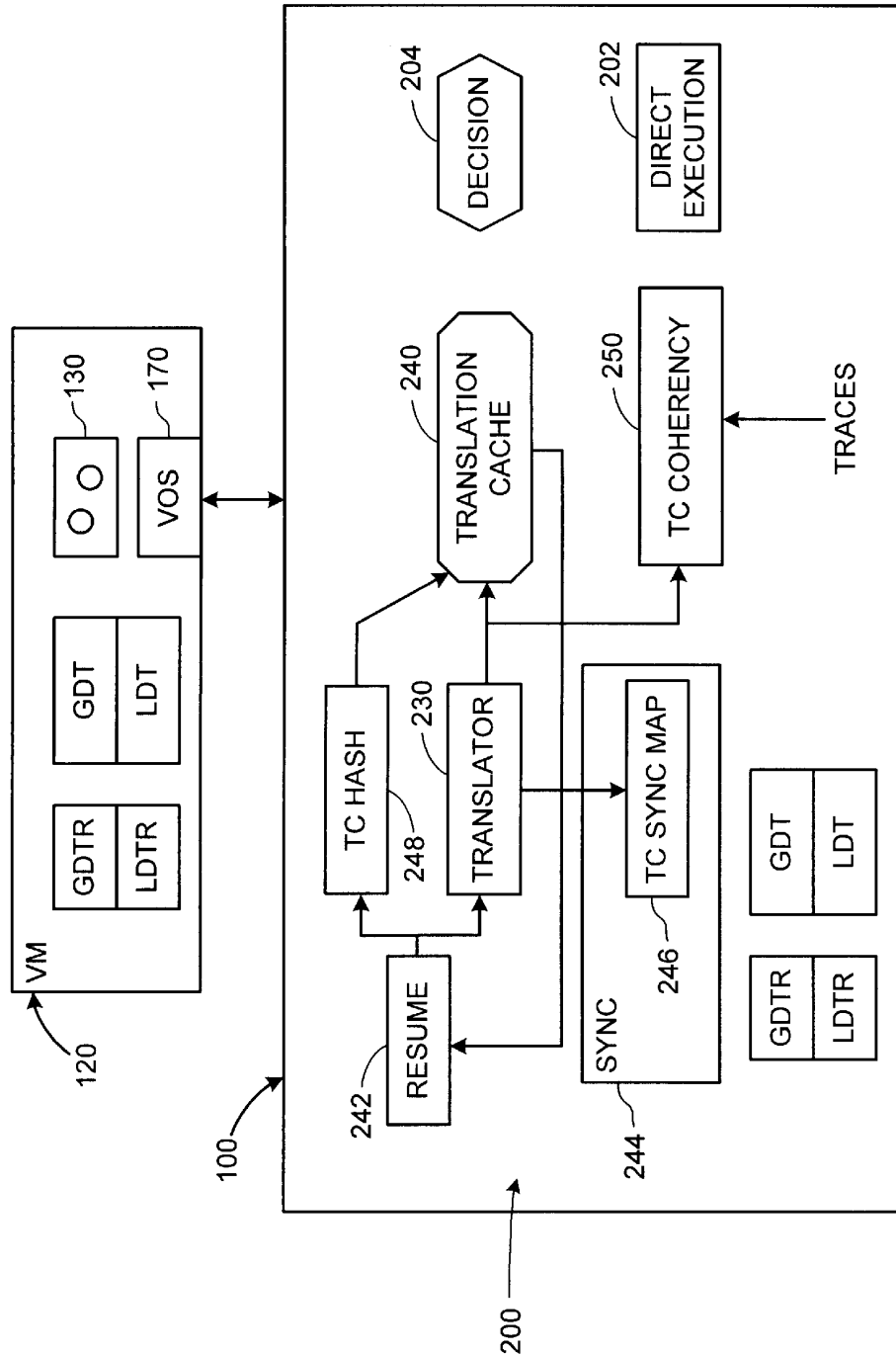


FIG. 2

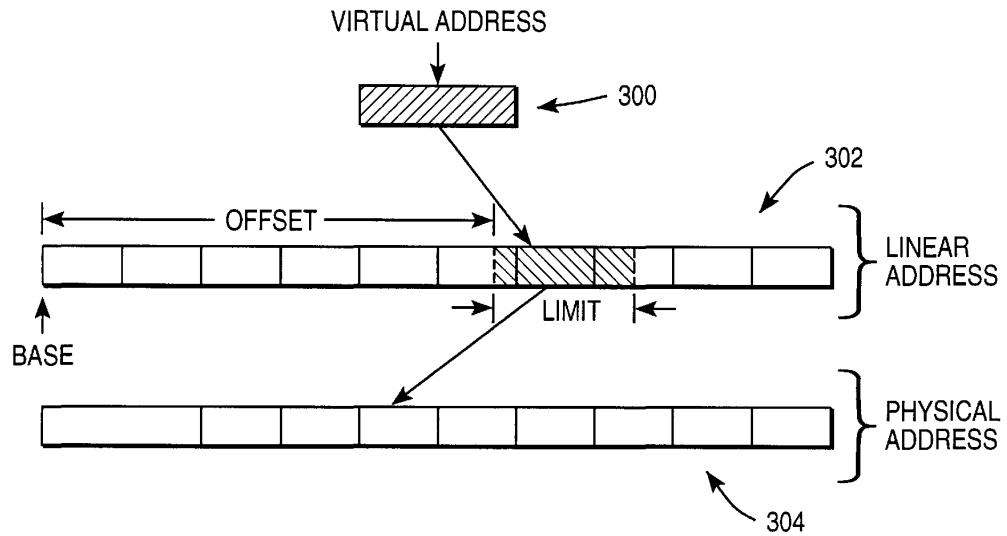


FIG. 3

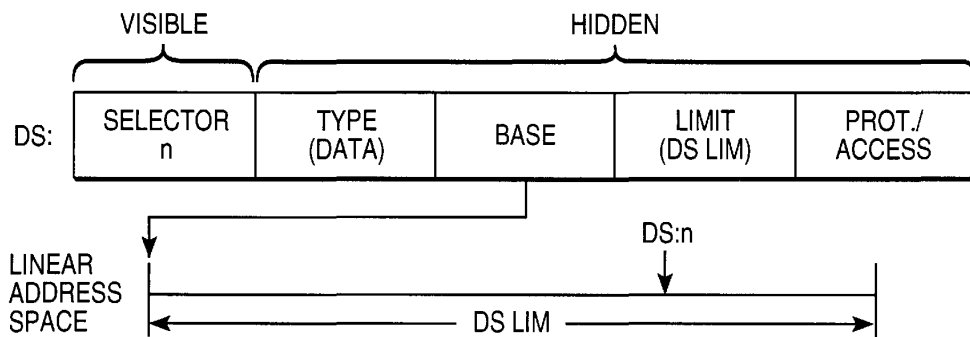


FIG. 4

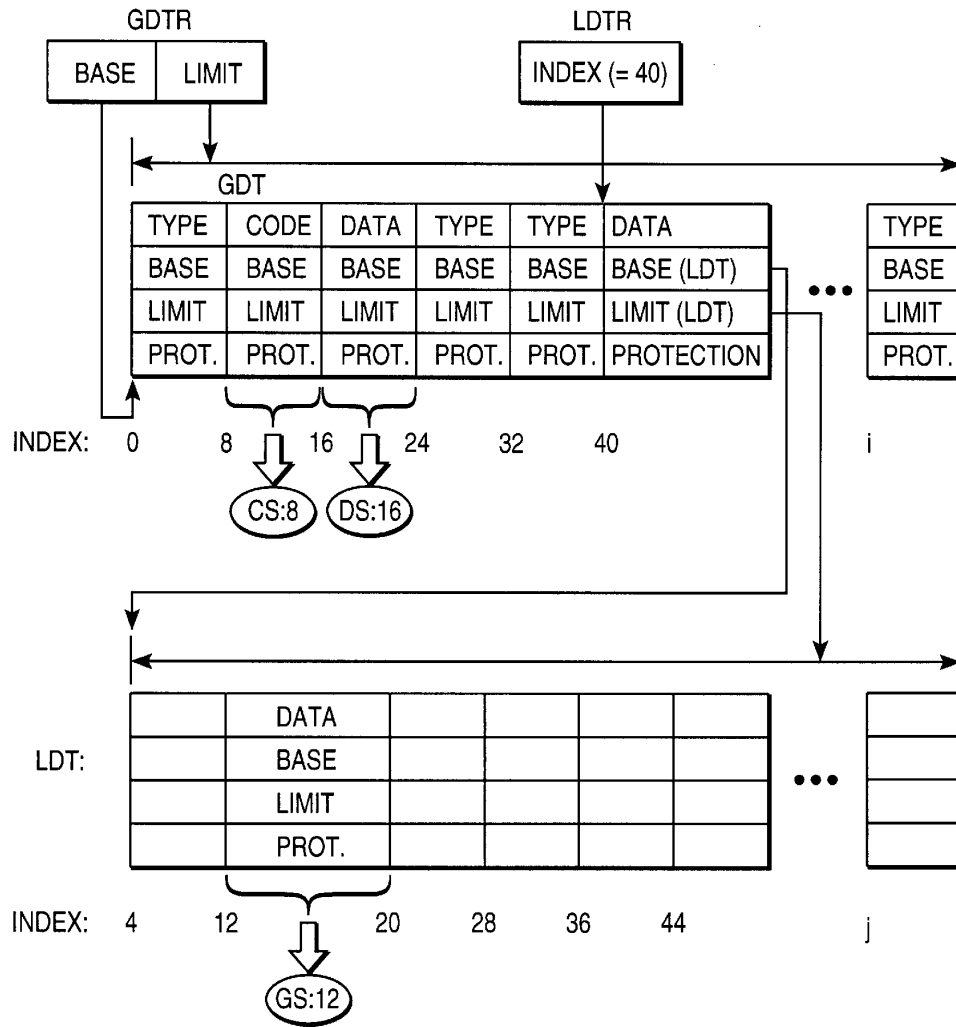


FIG. 5

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.