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Studies on Computer Systems Simulation

Hideo AISU (相 暁 秀 夫)

1. Introduction

With the advent of the computer technologies, the organization of computer systems has been increasingly extended and complexed. The detailed design of the systems can not be completed until several system design criteria are established. The complexity of the proposed systems makes it extremely difficult to analyze their dynamic characteristics, and thus to have an optimal design. Even the existence of the systems can not be justified on the basis of simple mathematical calculations. Therefore it is an important research subject to develop a method to simulate computer systems.

As far as computer systems simulation is concerned, it has not sufficiently developed, since the computer systems are so complex that it is impossible to describe them virtually in terms of a set of mathematical equations. It might be consequently considered that the only way of analyzing the behavior of computer systems would be describing them explicitly with using another computer.

The main object of this thesis is to propose a practical and exact mean of simulating computer hardware systems, and then to illustrate the feasibility of the proposed method through applying it to an existing computer system. Moreover, it is also necessary to indicate that the simulation is a useful tool for a quantitative performance evaluation, and is crucial in improving the design of computer systems. Details are given of the proposed method and the experiments of the simulation as well as the discussion associated with the procedures and techniques used in designing and carrying out the simulation.

2. Simulation models

The most important problem in systems simulation is to formulate a set of models and to verify or validate them. The models should pinpoint its rate-limiting aspects and predicate system's relations under a wide range of conditions.

The author proposes a method to set up models directly from the flow charts of control that are derived from the logical design of computer systems. It is shown in general that the flow charts can be classified into eight different functional blocks, and that in any cases the formulation of the computer models means to provide the models of these functional blocks. The models set up in this manner simulate completely and exactly actual computer systems. Another feature lies in the easy model building and preciseness without the necessity of verification.
It should be also noted that it is possible to apply the proposed method to the stages of design automation and to the logic simulation.

8. Programming languages

The matter of writing the actual computer code that will be used to run the models on a computer should be carefully considered.

In order to facilitate the programming of systems it is always necessary to select a powerful programming language for describing the models effectively. Therefore, from a practical point of view, the functional characteristics of various existing simulation languages have been compared, and then GPSS II (General Purpose Systems Simulator Model II) is selected as the best suited simulator for the studies.

In writing the simulation programs in GPSS II, the relationship between the abovementioned functional blocks and the capabilities of GPSS II is precisely discussed.

4. Input data

Input data that represent running status are preconditions for simulation. They can dramatically alter the loading, thus the behavior of computer systems. However, it is not part of this work to treat these influence explicitly. Input data are mainly collected through observing some typical programs written for other existing computers. The simulator therefore traces the programs in time of the input data through the computer models, observing the interlocks necessary to make the system behave correctly.

5. Experiments

In order to ensure the possibility of the proposed simulation techniques, an actual illustration is given.

The author has already developed a high-speed large scale computer, called the "ETL Mark VI", in which many particular ideas for speeding up the computer have been incorporated. As an example, the utilization of a fast memory as a logical buffer, which is referred to as a program stack, storing a small amount of program is one of the most fascinating proposals on the ETL Mark VI computer.

The dynamic behavior of the ETL Mark VI system is quantitatively evaluated by the proposed systems simulation. The actual detailed procedures for the simulation experiments are described.

Some of the results obtained from the experiments are summarized below;

(1) The priority levels of access to the memories are consistently decided.
(2) The quantitative performance of the program stack is explicitly evaluated.
(3) The real effect of the high-speed registers is investigated.
(4) The utility factors of main resources in the hardware system are obtained.
(5) The queuing status in the system are analysed, and the bottlenecks of the behavior are dictated.
(6) The balance of speed between the memories and the logical circuits is discussed.
(7) The real effect of the advanced control incorporated in the system, and of its probable future change are observed, and then suggests what the most economical control scheme is.

The above results of the simulation experiments have actually reflected to the better improvement choice for the ETL Mark VI system.

6. Conclusions

It is shown here that the proposed approach is a practical and convenient way to computer systems simulation, and that it has a wide variety of application fields, even in the stages of design automation.

The experiments also illustrate that detailed observation of the system being simulated may bring more significant information on the design criteria, and may lead to a better understanding of the system and to suggestions for improving it, which otherwise would not be obtainable.