Experimental Adaptive Model-Based Diagnostic System

ABSTRACT

The purpose of the experimental system is to realize efficient and robust diagnosis. To achieve this goal, we have investigated a model-based diagnosis technology which utilizes a model of the target device, an adaptive diagnosis mechanism with learning capability, and a parallel processing technology.

FEATURES

Model-based diagnosis

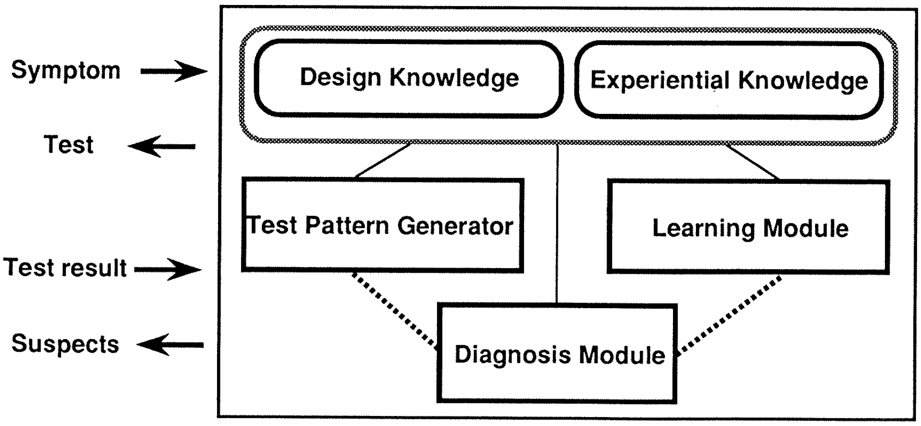
It performs model-based diagnosis, utilizing knowledge about the structure of the target device and the function of each component. This eliminates the necessity of interviewing experts in order to build a diagnostic knowledge base.

Adaptive diagnosis mechanism with learning capability

It learns fault probability distribution, based on its diagnostic experience, in order to pinpoint the faulty component with minimum number of tests.

Parallel processing

Parallel computation on Multi-PSI machine reduces the computation time for the diagnosis and the learning function.



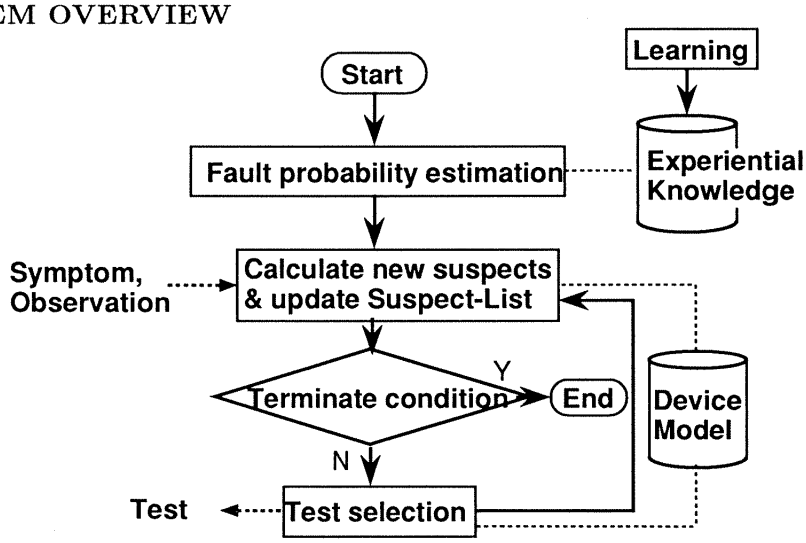
System Configuration

RESEARCH GOAL

Advances in modern technology have produced complex electronic devices, such as switching systems, and their maintenance tasks have become seriously difficult. A solution to automate the maintenance task is the expert system technology, which represents interviewed expert knowledge in a rule form. However, the technology has been applied to only small scale devices, because the knowledge base construction is difficult. To eliminate this problem, model-based diagnosis approaches have been investigated. Since model based systems utilize design knowledge of target device structure and behavior, they do not require expert interviews. However, because they lack experiential knowledge of human experts, it can not perform efficiently.

The research goals are, to add a function to utilize experiential knowledge to model-based diagnosis systems, to realize an efficient learning function which acquires the experiential knowledge from past cases, and to realize parallel implementations of the complex functions for fast computation.

SYSTEM OVERVIEW



Terminate condition: # of suspects =1 or no available test

Basic System Flow

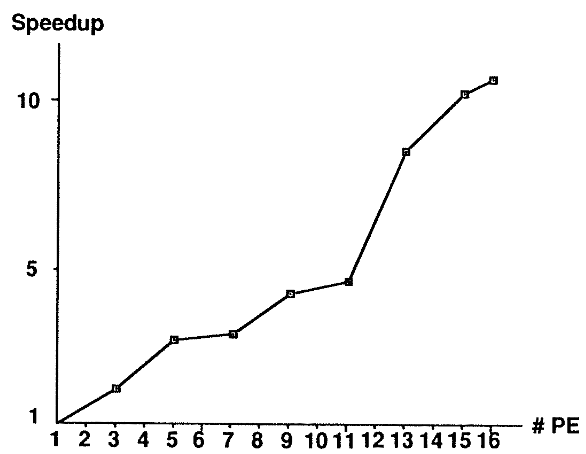
The learning function of the system first estimates fault probability distribution for each component from the past case record. This learning is performed by an inductive learning algorithm, which is based on MDL measurement. This complex task is processed in parallel.

Then the system calculates the suspect list for given symptom and observation data. This task is performed by utilizing a model-base knowledge which models behavior and interconnection of the target device components. This model knowledge is represented in first-order predicate scheme and written in the logic programming language KL1. The system computes the suspect list by a hypothetical reasoning which calculates a set of explanations of giving the faulty output for the given input data on the device.

The system repeats selecting a test and executing the test, until it reaches a termination condition. In order to select the most effective test, it computes information gain for each candidate tests by calculating entropy, based on fault probability distribution. This function is also complex and implemented in parallel.

EXPERIMENTAL RESULTS

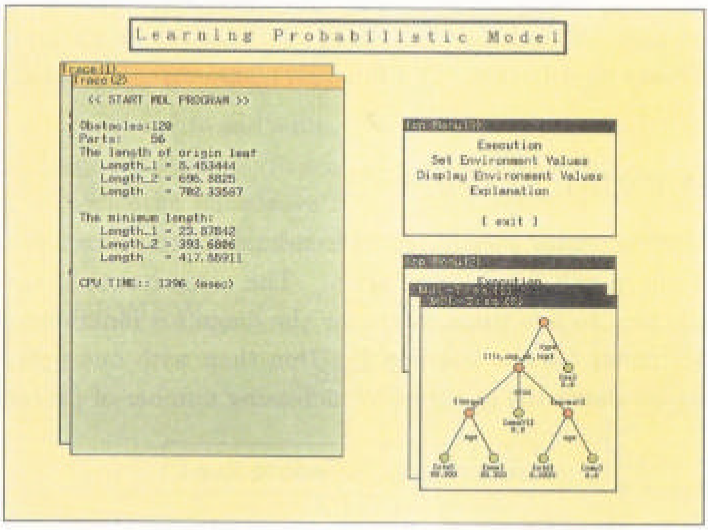
Several experimental executions have been performed to show the effectiveness of the parallel implementation. The computational time with 16 processors is four to five times faster for the diagnosis function and eight to eleven times faster for the learning function than with one processor. The following figure shows the speedup by increasing number of processors.



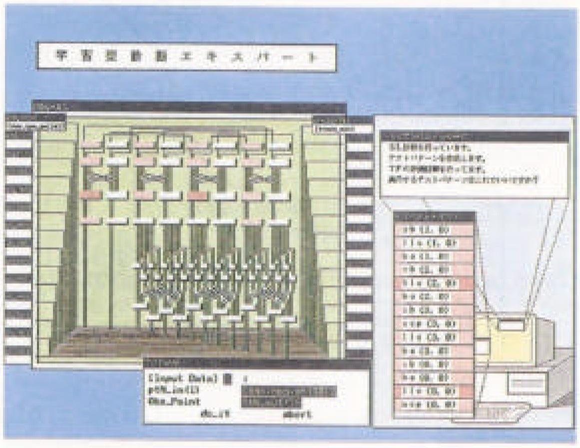
Speedup by Parallel Implementation of Learning Algorithm

OUTLINE OF DEMONSTRATION

An example model base for a packet switching device with 70 components is used for the demonstration. The system first shows the result of the fault probability estimation by the learning function. Then, it repeats test selection and execution cycle to pinpoint the faulty component, against a simulated faulty device model. The process of the diagnosis is shown graphically on the display which expresses fault probabilities with different color brightness. The parallel execution is performed on a Multi-PSI machine.



Result of the Learning Function



Diagnosis Session