Research and Application of Computer Aided Analysis and Optimization Algorithm for Fault Tree

Chao Liu
{ liuchaowh@163.com}

Department of Computer, Wuhan polytechnic Wuhan 430074, China

Abstract. This paper describes the computer aided fault tree analysis principle, the fault tree of main parameters (minimum cut sets, the minimal path sets and disjoint minimal cut sets, the minimum path set between the transformation rules, achieved by cut set, path set compared with each other by fault tree qualitative analysis algorithm and the direct no cross is used to realize the quantitative analysis of the fault tree of the new algorithm. The reasonable application of these new algorithms can effectively reduce the difficulty of NP FTA, and provide a new way for the simplification of FTA. With C++ language in the VC development environment developed a fault tree qualitative and quantitative analysis of computational program components, and developed a set of FTA analysis software based on this component. This software has applied the theory of optimization algorithm, which has the main functions of the minimum cut set and the minimal path set calculation, the calculation of availability, the importance calculation and the fault diagnosis based on fault tree. In fact we use the higher order arrays reducing dimension technology and dynamic numerical method, when complete the calculation function of a dynamic array, immediately release the memory space occupied by, faster to meet the demand of computer for large fault tree analysis. Through the fault analysis of some fault trees and the comparison with other software, it is proved that the optimization algorithm and the application software are scientific and effective. Finally, through the further research on the specific application of the optimization algorithm and the software in the field of safety evaluation and fault diagnosis, it shows that the optimization algorithm and the software has a good practical value in engineering.

Keywords: Fault tree analysis method; qualitative analysis; quantitative analysis; Boolean operation and non intersection; fault diagnosis

1 Introduction

With the development of the comprehensive quality management and reliability engineering, more and more attention has been paid to the status and function of the new quality concept and reliability design analysis. Cost and effectiveness are the key factors to be considered in the development of any product. At present, the reliability and maintainability engineering has been widely used in military, telecommunications, electronics, information industry, it has become to improve system performance and safety, enhance the ability to survive, to save manpower and reduce the cost effective way [1]. As the quality of the products is the most important feature of reliability and maintainability throughout the product life cycle. Product quality and reliability level is an important symbol of the economic strength

of a country, countries in the use of computer aided reliability and maintainability prediction, allocation, design, analysis and other means to improve the quality and reliability of the product. Large mechanical system such as oil drilling, mining, automobile manufacturing, aviation, navigation, nuclear industry, hydro and thermal power plants and other are more and more widely in the industry and in the development of the national economy plays a pivotal role. The system safety and reliability level of high and low is not only related to the interests of enterprises and the local social groups, but also related to the whole nation status in the world economy and politics, the military, so for large mechanical systems usually reliability, safety, maintainability and supportability etc. analysis. Thus the development for large and complex mechanical equipment of computer aided reliability, safety and maintainability of software has become a focus of the field. Reliability engineering and maintenance software must be combined with the actual situation of China's reliability and maintainability engineering application, according to the domestic and foreign advanced reliability and maintainability criteria and design analysis method, financial reliability modeling, expected, distribution, analysis, design, management in one. It should be strong reliability engineering auxiliary means is accurately predicted and reasonable allocation of reliability and maintainability index, reliability design, carry out FMECA and FTA analysis, establish fracas system an important tool, is the implementation of monitoring project, improve the quality and reliability of system life cycle, save product development costs of the important means and product reliability and maintainability design truly complete solutions. With the increasing emphasis on the importance of reliability and maintainability index, reliability and maintainability design has gradually been recognized. The application of reliability and maintainability engineering software reliability design is an inevitable trend. And people with computer technology, the main problems in reliability engineering data statistics such as reliability analysis, reliability prediction, allocation, fat, FMECA, fault analysis, optimization design, reliability design, reliability calculation, reliability evaluation and, problems can be solved by using computer aided method, realization of reliability engineering computer that is care, not only can quickly complete the reliability analysis and calculation of a heavy, and will greatly promote the development of reliability engineering [2].

2 Computer Aided Analysis Algorithm based on Fault Tree

In the fault tree analysis, the achievements of the key is to clearly understand the analysis of system logic relation and failure mode, effect and criticality. Achievements perfect or not directly affect the qualitative analysis and quantitative calculation results are correct, the fault should be the actual system fault combination and transfer of the logical relationship is the correct Abstract. The contribution to the process is the engineering and technical personnel of the system analysis thinking process, through different angles of the contribution to the process, staff analysis further information systems and more familiar with the system, can help designers to ascertain potential fault, so as to improve the design, improved operation and maintenance program. Contribution to the work more complex, it should be designed by the system, the use and reliability of experts in close cooperation, and should continue to develop, and gradually improve.

2.1 Fault Tree Construction

First, analysis of the various components of the system function, structure, principle and fault state, and fault factors and its influence, and thorough understanding, identify a don't want the top event, which began, step by step to find out events of different levels of all possible direct cause, and so the tree barrier symbolic representation of all kinds of events and their logical relationship until analysis to the bottom of the various events to. Generally carried out according to the following steps:

(1) Familiar with the system

Prior to a system of fault tree analysis, contribution first response to the system function, structure principle, fault state, and fault factors and the influence of for thorough understanding, to collect information on the technology about the system. Which is the achievements of basic work.

(2) To determine the top event

The top event can be according to the object of our study to select, usually top event is a system does not wish to fault events, in order to be able to analyze and top event must be clearly defined, to quantitative evaluation, and can be further decomposed into it. A system may have a number of undesirable event, so you can establish a few pieces of fault tree, but only a fault tree from a don't want to analyze events, it is necessary to choose and design, analysis to the most relevant events as achievements of the initial event, i.e., the top event.

(3) Construction of fault tree

Starting from the top of the event, step by step to find out events of different levels of all the direct cause of, and with fault tree of symbols to express all kinds of events and their logical relationship until analysis in the end event so far, obviously, for an auxiliary system constructs a single fault tree need huge workload, achievements can be divided into two categories: artificial achievements, basically by the deductive method, namely of system at all levels of fault events were logical reasoning. The second kind is the computer aided construction, at present this is a very active research topic [3].

(4) Simplified fault tree

When the fault tree is formed, it is necessary to start from the lowest level of the fault tree, and then write the logical relationship between the superior and the subordinate. And combined with the logical operation algorithm to do further analysis, delete the redundant events.

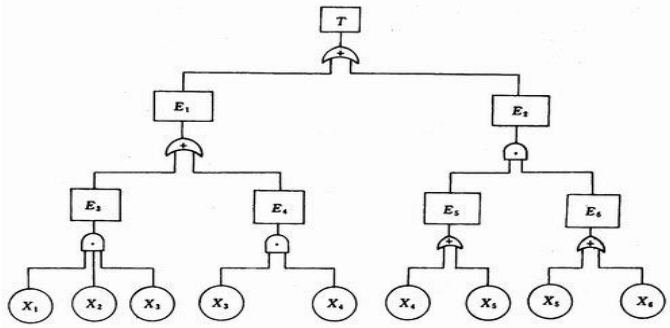

Fig. 1. Sketch map of fault tree

2.2 Qualitative Analysis of Fault Tree

This paper mainly introduces the determination of the structure function of the fault tree of the monotonic correlation system. So-called coherent system refers to the system in each component are system related and system structure function is monotone non decreasing, said the system into a coherent system, coherent sysetm, nor redundant logic element, monotone systems components, composed of and gates and or gate structure of the fault tree are coherent system (no inverse event structure). The monotone correlation system has the following properties:

(1) Each component of the system has a certain impact on the reliability of the system, but it only affects the degree of different size;

(2) All elements and components of the system are normal (fault), then the system is normal (failure);

(3) The failure of the system in the system, parts of the repair will not make the system from normal to failure; the normal component of the fault will not make the system from failure to normal. That is, the more fault elements, the more the system, the more easily the fault;

(4) The failure probability of any monotone system is not worse than that of the series system which is composed of the same parts, and it is not better than the parallel system which is composed of the same components.

In short, the monotonous coherent system is that there is no and system independent components of monotone systems, in reliability analysis is carried out and the Boolean operation, independent components to eliminate the natural, therefore monotonicity is the main properties of the coherent system. The fault tree of any given static monotonous coherent system, could be for doors or and gate and bottom events of the basic fault tree contains only, and structure function write fault tree of mathematical expressions. Because of the structure function has nothing to do with time, so the fault tree can not be expressed by the structure function, and the theory of Markov state transition is needed [4].

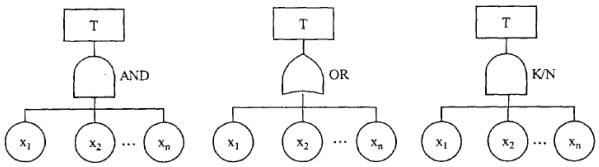

Fig. 2. With, or, N system structure K

2.3 Quantitative Analysis and importance Calculation of Fault Tree

The purpose of quantitative analysis of fault tree is the use of fault tree for the calculation of the model, according to the bottom event probability for top event probability and bottom events important degree, the probability importance degree and the structure important degree, and the reliability of the system, resulting in the loss of serious, the safety of risk assessment. The specific use of minimal cut sets of fault tree quantitative analysis, or the use of the path sets of fault tree quantitative analysis (dual tree), depending on the minimum cut set number and size and the path set for comparing the number and size. The general minimum cut set number is small, the minimum cut set is used for quantitative analysis, the number of the minimal path set is small, and the minimal path set is used for quantitative analysis.

3 Research on Optimization Algorithm of Computer Aided Analysis of Fault Tree

Fault tree analysis is the key to solve the fault tree of the minimum cut sets, the minimal path set, disjoint minimal cut sets, disjoint minimal path set, so as to carry out qualitative and quantitative analysis. However fla in solving the minimum cut set, disjoint and quantitative analysis etc., sometimes the quantity huge calculation, this is FL 'a NP problem, namely computation of the FTA with the scale of fault tree bottom event number N and logic gate number n) increase and exponential growth. It is an effective way to simplify the FTA and effectively reduce the NP problem by finding the simple algorithm for solving the minimum cut sets, the minimal path set, the minimal cut sets and the disjoint minimal path sets of the fault tree, which are the four main parameters. Different structure of the fault tree, in the calculation of the complexity of the four parameters and the amount of calculation is very large. So find a way to mutual conversion between them, to develop efficient algorithms in order to be able to adopt different computational paths of different structure of the fault tree, to reduce the amount of calculation for fault tree analysis, to overcome the difficulties of NP is important. Fault tree analysis to get the minimal cut sets and the disjoint minimal cut sets and disjoint minimal path set, because the minimum cut sets, resulting in failure of all the modes, and the disjoint minimal cut sets or disjoint minimal path set can calculate the top event occurrence probability, bottom event and the probability importance degree and the critical importance of and complete the quantitative analysis of fault tree. Therefore, this paper on the mutual transformation of the main parameters of fault tree based on, through the analysis of the characteristics of fault trees with different structures, while the introduction fault tree early disjoint algorithm and quantitative analysis of the new method, with minimal cut sets and the disjoint minimal cut sets or disjoint minimal path set for the results and analysis of the following five kinds of fault tree analysis algorithm [5].

4 Conclusion

This paper to the safe running of the equipment and maintenance maintenance of intelligent management system in reliability analysis as a starting point, with "computer aided fault tree analysis optimization algorithm research and application" in the title, the fault tree analysis method is studied, and the development of the computer aided so fault tree analysis software, capable of arbitrarily complex fault tree qualitative and quantitative analysis of the calculation, all code written by C + + program, package is good, easy to expansion and secondary development. Finally, the paper studies its application in safety assessment and fault diagnosis.

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