THE SYSTEM FAULT BEHAVIOR AND MODEL

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Abstract

*After describing the backgrounds and requirements of system fault behavior modeling, this paper traverses the concept and connotation of system fault behavior in detail and presents its definition and classification. Upon these, this paper also lucubrates the method and idea of how to build the system fault behavior model, builds the system **F**ault **B**ehavior **M**odel (FBM) and analyzes its characters.*

1 Introduction

System non-functionality, namely reliability, durability, environment adaptability, maintainability, testability, supportability and safety so on and so forth, is emphasized greatly with the enhanced knowledge of aeronautic equipment. Fault is an attribute closely related to these non-functionalities. The cognition and description of the fault rules make the basis of system non-functionality design. These years, reliability theory research is gradually making the transit of facing “fault time” to facing “fault process”. Study on fault process includes two aspects: micro-aspect and Macro-aspect. The former is from the view of failure physics, focuses on failure mechanism. The latter is from the view of fault behavior, focuses on fault propagation. Fault behavior modeling is to make further understanding of system fault engendering and behaving rules, and to describe system fault occur and develop process from the view of behavior.

2 Concept of System Fault Behavior

2.1 System and System Fault

System is a complex whole with some function, which is composed of certain units contacting, restricting and interplaying with each other[1]. System fault refers to the event or state which the whole or some units of the equipment could not finish the predicted functions. It is a system familiar state, namely non expected sate.

2.2 Definition of System Fault Behavior

Behavior is defended as the system changes as time goes. In behavior, behavior refers to the activity form, phonation, posture and some changes distinguished in appearance of the animals. All the changes make effects to communicate with each other, and could arise an action mode of another animal[2]. The behavior described in this paper is the activity, state changes of each unit composed of the system and the dynamic process as the system in fault. The behavior is the reactions of system in response to external or internal stimuli. They are in contact with each other and make an effort on each other. The behavior is a sequence- aggregate representing fault events transfer.

System fault behavior indicates the change of system state which deviates from the predicted function. It appears to make changes as time goes. It reflects not only the basic unit fault behavior influenced by intrinsic and extrinsic factors but also the relationship between different basic unit fault behaviors—a fault behavior causes another. System fault behavior is decided by system composing, structure and potential external stimulation.

According to system approach, interaction exists between fault behaviors. And system fault behavior is the result of fault behavior propagation rather than simple addition of individual behavior. After summarized, System fault behavior was classified as Ⅰ, Ⅱ and Ⅲ in this paper.

SYSTEM FAULT BEHAVIOR Ⅰ: refers that the system fails in function because of the faults of the composed units.

SYSTEM FAULT BEHAVIOR Ⅱ: refers that the system loses its function because of not the fault but the influence in units

SYSTEM FAULT BEHAVIOR Ⅲ: refers that the system could still finish its function although the units are in fault.

System fault behavior includes unit fault behavior and whole fault behavior.

UNIT FAULT BEHAVIOR: refers to the fault behavior of the unit itself.

WHOLE FAULT BEHAVIOR: refers to the system whole fault behavior after the unit fell in fault. It is made up of a series of unit fault behavior.

2.3 Description of System Fault Behavior

From reference [3] we know that system fault comes into being in the effect of the synthesis of intrinsic factors and extrinsic factors. The exterior behave of system fault takes on determinacy, randomicity and fuzziness. Thus, the description of system fault behavior should reflect all these characters of system fault above. So the description of fault behavior is defined as follows

System fault behavior is defined as a vector of four dimensions, let

Beh＝(P, E, T, S)

Where, P(**P**roperty) is the property of system unit, which includes structure, material and technics etc.

E(**E**nvironment) is the external influence factors sets, which includes usage mode, environment, human factors etc.

T(**T**ime) includes general time, which describes the moment of a certain fault behavior in the system operational process, and part time, which describes the developing process of a certain fault behavior.

S(**S**timulate) is the stimulus on system unit, which includes stimulant and stimulus intensity.

Every system fault behavior should include all the attributes above. This definition ensures a complete description of intrinsic and extrinsic factors influences, and also reflects the determinacy, randomicity and fuzziness of system fault occurring.

3 Classification of System Fault Behavior

System fault behavior can be described in two deferent points of view, failure mechanism and exterior behave. The latter defines and describes unit fault behavior in exterior behave. It describes the relationship between the unit inputs and outputs, which are expressed in electric current, voltage, pressure, altitude and other performance parameters. According to the relationship between behaviors, fault behavior could be classified as follows.

(1) Ordinal Fault Behavior

Ordinal fault behavior refers that the fault behavior happens in sequence of time. For two kinds of faults, B fault behavior happened only after A fault behavior happens. In fault promulgate, that is to say, A fault behavior happening is the precondition to B fault behavior happening. It is showed in figure 1.

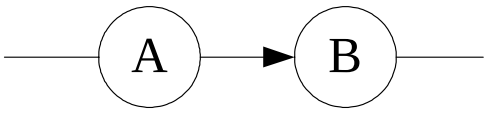

Figure. 1. Ordinal Fault Behavior

(2) Intercurrent Fault Behavior

Intercurrent fault behavior refers that more than one fault behavior action to the same object happen at the same time. The behaviors have no restriction and associate relationship. It is showed in figure 2.

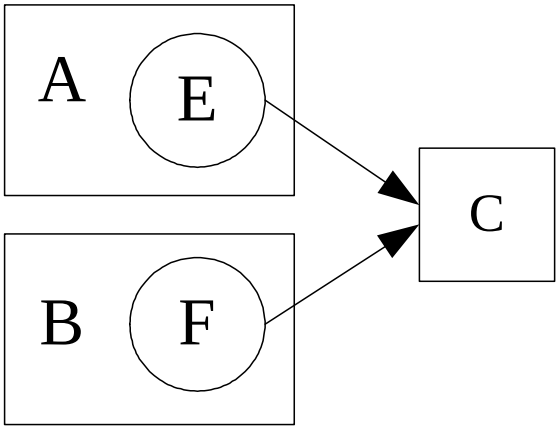

Figure. 2. Intercurrent Fault Behavior

(3) parallel fault behavior

This kind of fault behavior refers that deferent fault behaviors action to deferent objects happen at the same time. The behaviors do not correlate and affect with each other. It is showed in figure 3.

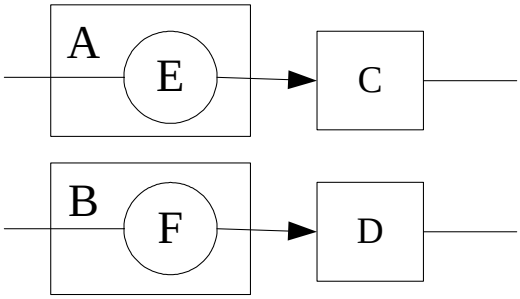

Figure. 3. Parallel Fault Behavior

(4) Scrambled Fault Behavior

Besides fault behaviors have time sequence, they are opposed each other sometimes. Behavior modes ostracize each other, that is the appearance of one behavior could prevent or intermit other behaviors, which is called scrambled behavior. It is showed in figure 4. C behavior and D behavior are scrambled behaviors. E is the replace behavior, which happens when C and D were triggered at the same time and their stimulus intensity equals or they restrict to each other.

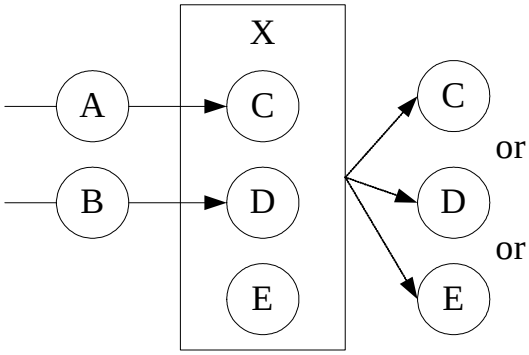

Figure. 4. Scrambled Fault Behavior

(5) United Fault Behavior

This kind of fault behavior refers that several behaviors, which received stimulus are under threshold, trigger some behavior subject to one object, they produce united effects to make the stimulus achieve the threshold. It is showed in figure 5.

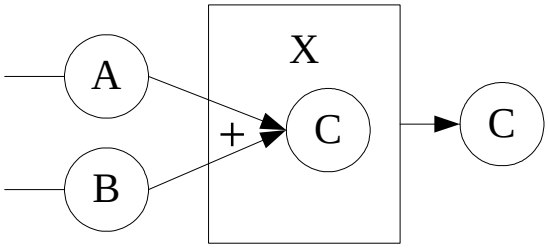

Figure. 5. United Fault Behavior

4 System Fault Behavior Model

The behavior model is to describe the dynamic behavior process of system and equipment change and develop as time goes. The fault behavior model is to describe the development and change of system behavior when the units fall in fault or are disturbed by external influence factors. That is to say, the main task of fault behavior model is to describe the system fault occur and develop process, accordingly analyze and acquire the influence of fault on system.

4.1 Definition of System Fault Behavior Model

On the basis of the study above, a fault behavior modeling approach which considered multi fault behavior influence factors was proposed, and a theoretical model of system fault behavior (FBM, Fault Behavior Model) was built, which is the composition of system structure, behavior and environmental information.

Fault behavior model (FBM) is defined as a vector of three dimensions, let

FBM＝(OBJS, B, E)

Where, OBJS is system object sets, which includes basic units at product different levels.

B is fault behavior sets. Different fault behavior belongs to different objects.

E is external influence factors sets, which includes usage mode, environment, human factors etc.

Object sets reflect inherent attributes of system composing, including system structure, material, technics etc. External influences factors sets reflects external stimulus such as environmental factor, usage factor etc. Fault behavior sets which reflects system behavior changes, is the state transfer of system as time goes.

4.2 Framework of FMB

The framework of FMB is shown in figure 6 according to FMB definition.

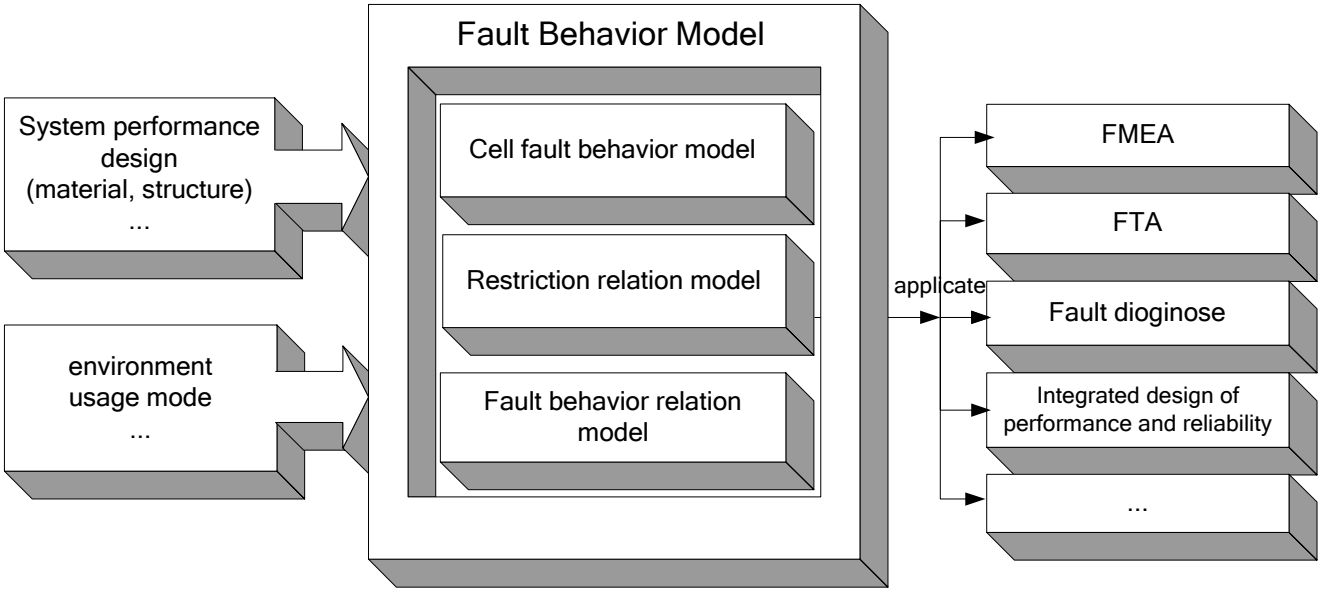

Figure. 6. The Frame of FBM

The system fault behavior model is built according to system performance design including functional drawing, the unit material and other parameters, and external influence factors including environment condition, using mode and other factors, to describe the rule of system fault. FBM includes three parts:

- BASIC UNIT FAULT BEHAVIOR MODEL
- RESTRICTION RELATIONSHIP MODEL
- FAULT BEHAVIOR RELATIONSHIP MODEL

Basic unit fault behavior model is for every unit composed of the system. Restriction relationship model applies to the factors in external influence factors sets. Fault behavior relationship model is for all kinds of trigger relationships between fault behaviors. Restriction relationship model produces restriction condition on basic unit fault behavior model, all basic unit fault behavior models joint into a whole then through fault behavior relationship model. Thus the system whole fault behavior model could be built.

On the basis of the detailed description of system fault behavior model, FBM could be applied in FMEA, FTA, fault diagnosis, the integration of performance and reliability and other applied techniques.

4.3 Structure of FBM

FBM is a complex entity with certain function, which comes into being through every level based of the attributes of each unit.

FBM system building starts with system functional drawing, and acquires the physical connected relationships between system and their units, then abstracts their behaviors and builds their relations. FBM has multi levels including system structure level, behavior level and restriction level, and its goal is to realize to describe system fault occur and develop process.

As considering both the intrinsic factors and the extrinsic factors which result in system fault, this paper build FBM architecture as three levels: structure level, behavior level and restriction level, which is shown in figure 7. The model describes the system fault behavior process and the fault information propagation.

Structure level reflects the static structure between basic units. Behavior level reflects the dynamic fault behavior process of system and system units. Restriction level reflects the restriction on system and system units. The whole model expressed the system hierarchical relationship, associated relationship etc, adequately. In addition, it describes the trigger-characterized dynamic behavior process.

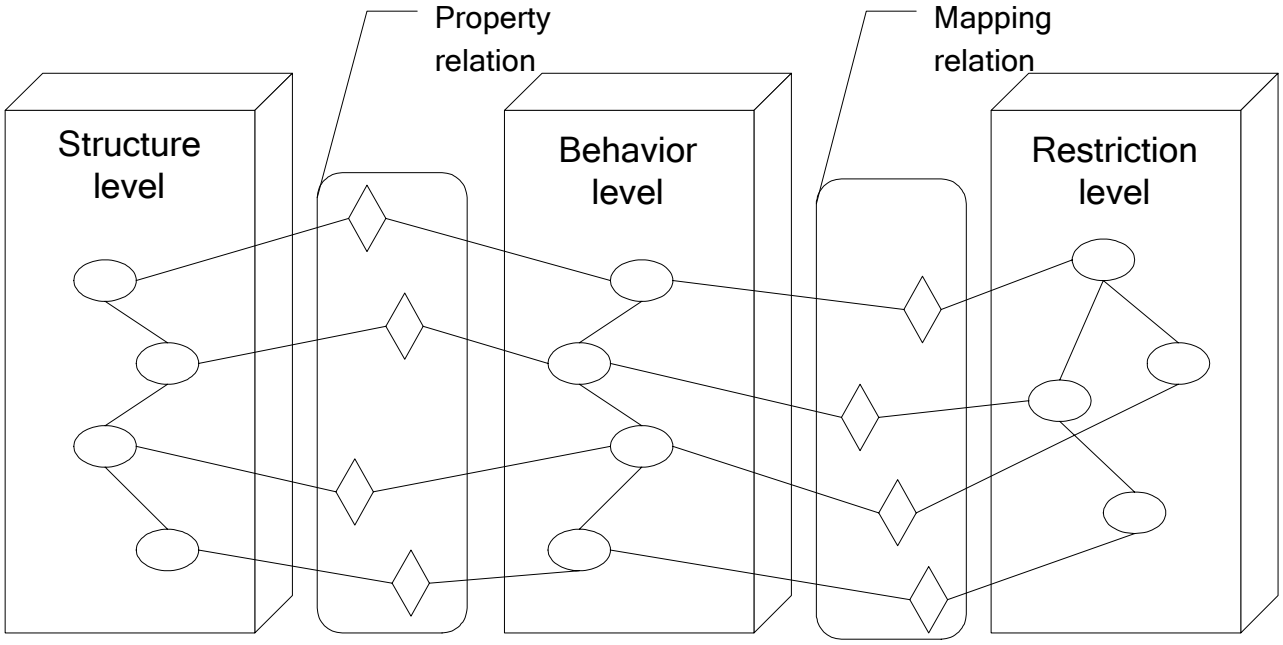

Figure. 7. The Architecture of FBM

The model is built according to system structure. The units in different levels are abstracted as objects. Different objects have not only hierarchical relationship but also cooperated relationship and associated relationship, which are reflected by behaviors. The connections between behaviors are controlled by restriction. That is the relations between objects also depend on restriction. The object hierarchical relationship include the inherit relationship and manage relationship, which could build a static object tree. Cooperated relationship refers that deferent object work together to trigger a behavior happening. Associated relationship refers that one object behavior can trigger another object behavior. The whole model is a trigger-characterized dynamic behavior process.

5 Characteristics of FBM

The system fault behavior model is a model building the dynamic behavior change process of system and its units in system fault view and acquiring the influence of fault on system. It has several representative characteristics.

1. the hierarchical description

Hiberarchy is the most representative characteristic of FBM. From the whole model to the part model, FBM adopts the hierarchical description. The hiberarchy is showed in the following aspects.

- In functional aspect, FBM is with the architecture of three levels: structure level, behavior level and restriction level. It builds the contacts between all levels to finish describing the whole system.
- In structure aspect, FBM builds the hierarchical model from the whole system to the unit. Each level in the model includes the object structure description, behavior description and restriction description. The contacts and effects on deferent level objects are acquired by integrating analysis of these three descriptions.
- The classification and description of system fault behavior adopt hiberarchy.

The hiberarchy is competent to system feature description and fault effects analysis.

(1) The hiberarchy is intuitionistic, so it is easy to describe, design and diagnose.

(2) The hiberarchy helps to decompose the problem, is easy to transfer the complex problem into a simple one.

(3) The hiberarchy is easy to build and analyze the system for deferent level user. The designer is entitled to build and analyze each level system and synthesize multi models in deferent levels conveniently.

(4) The object and behavior at higher lever could contain the object and behavior at lower level, and have the ability to acquire the lower level object transaction processing.

(5) The hiberarchy is convenient for information processing.

(6) The hiberarchy is convenient to determine fault effects and acquire the influence degree of fault on the system.

2. building models up to down and analysis bottom to top

One perpose of FBM is to describe system fault behavior occurring and developing process, and anther is to reason the influence of fault on system and analyze the system dependability.

As we know from emergence of system, the fault behavior of the system at higher level could not be forecasted by the system fault at lower level, and the changes of the lower lever system fault also have no effect on the feature and behavior of the higher level system fault. Therefore this paper adopts the up to down method in building FBM. According to system function, the users analyze the behavior and occurring condition which system might exist and connects into net structure up to down. As analyzing, according to rules, the users reason from bottom to top to acquire the influence of the bottom level unit fault on system.

3. describing dynamic behavior, promulgating fault information

FBM is a dynamic model, which describes the system fault behavior change process. On the basis of the unit behavior state defined with users, FBM searches and reasons the model according to fault promulgate mechanism, and describe the fault dynamic changes in system running process, consequently it could finish promulgating fault information. It is need no people do something and avoid the multifarious work and the effect caused by man.

6 CONCLUSION

This paper describes system fault in the view of behavior. It regards system as the body implementing behavior and thinks system on its own initiative and has the selectivity of behaviors after its fault. Therefore this method could describe system fault occurring, developing and disappearing process more clearly.

On the basis of deeply analysis of system fault behavior, this paper concludes the fault behavior into three categories: SYSTEM FAULT BEHAVIOR Ⅰ, Ⅱ and Ⅲ, and builds system fault behavior model—FBM. As started with describe the behavior, the model could describe system fault engendering and behaving rules, which provides effective technique supports on reliability design and analysis techniques such as FMEA, FTA and so on.

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