

## Integrated Methodology for Software Reliability Analysis

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*The most used techniques to ensure safety and reliability of the systems are applied together as a whole, and in most cases, the software components are usually overlooked or to little analyzed. The present paper describes the applicability of fault trees analysis software system, analysis defined as Software Fault Tree Analysis (SFTA), fault trees are evaluated using binary decision diagrams, all of these being integrated and used with help from Java library reliability.*

**Keywords:** *Software Reliability, Binary Decision Diagram, Fault Trees, Combinatorial Models, Analytical Techniques*

### 1 Introduction

Safety critical software systems refer to those systems blackouts that may cause catastrophic consequences, implying human and substantial material losses [10]. A variety of techniques is available and used to ensure safety and reliability to the system. Some of those include: HAZOP method (Hazard and Operability Analysis), which deals with risk study and system operability; fault tree analysis (FTA), used to analyze potential danger causes and FME(C)A technique (Failure Modes Effects (and Criticality) Analysis), used to check the proper system functionality.

Most of the techniques mentioned before, are applied together as a whole, and in most cases, the software components are usual overlooked or very little analyzed.

This paper describes an integrated framework for software reliability analysis using the following analyses and modeling techniques:

- software fault tree analysis (SFTA);
- binary decision diagram;
- Java technology for reliability.

In use of this analysis framework are followed these steps:

- it starts from a structural/functional analysis of the software system, in order to determine software's failure mechanisms (failures), based on which the fault tree is constructed. The program is seen from a structural point of view, taking in consid-

eration his components and the relations between them;

- after the structural - functional analysis is made, the primary events group (primary defects) and the group of critical events (failures) are identified, with the help of which the fault tree is built;
- using the resulted tree, different computation operations are made, such us tree minimization, through known methods, to ease the implementation process using the Java language;
- for the automated decision binary diagram generation an open source Java library is used, called JReliability (Java-based Reliability Library), library developed for modeling and analyzing the reliability of complex systems using BDD. Thus the most of the research was made on hardware systems in this paper the authors extends the library utility towards software systems;
- at last, after the BDD generation a quantitative analysis is made in order to evaluate the reliability indicators put at disposal by the JReliability, through the analytic results and through graphic representations.

First are presented the techniques used until the present and well researched in the field's literature: software fall tree analysis, SFTA and binary decision diagrams, BDD.

## 2 Combinatorial Models

Combinatorial models represents a structured approach of systems, forming a class of reliability models in which the causes of software failure can be expressed in terms of combinations of software components (modules) faults (failures) [4]. Combinatorial models include models with graphs used in network reliability analysis, fault trees and reliability block diagrams. These models do not require the fulfillment of constant failure rate assumption and have been successfully applied for reliability analysis of mechanical and electrical systems. In particular, failure trees were implemented also for reliability software analysis.

An alternative to SFTA [1] (a traditional approach of models with solutions based on minimal cuts) uses the so called binary decision diagrams (BDD) [2]. Binary decision diagram were used initial as a checking technique in electric circuit theory, but recently were adapted to resolve a failure tree model for quantitative and qualitative reliability analysis [12]. Because it seems that there is no connection between the number of modules (components) from a system and the dimension of the appropriate BDD, the BDD based solutions can offer efficient solutions techniques for big systems.

### 2.1. Failure Trees

An often used technique proven to be efficient for the software reliability analysis is the software failure tree analysis (SFTA). This technique borrows the failure trees concept (FTA) from the hardware field.

FTA technique represents a deductive approach, having the system failure mechanism as a base [17]. FTA starts with an unwanted event, such as “obtaining unauthorized access on a server”, and then determines (deducts) its causes using a backward systematic process, step by step. To determine the causes, a failure tree is built as a logical representation of events and the relations between them, which are necessary and sufficient to detect the unwanted event, called the top tree event (top event).

Failure tree represents a qualitative model which provides a useful set of information about the causes which led to the manifestations of the unwanted event - called the critical event. Also, the tree can be quantitative evaluated to offer useful information about the probability of the top tree event to be produced, as well as the defects' importance and the interdependence between them, modeled in the failure tree.

Itself the failure tree represents a graphic model of various parallel and sequential failures combinations, combinations which lead towards the manifestations of the predefined unwanted event. The defects can be events assigned to hardware components failures, human errors, software errors or any other event which can lead to the manifestation of the critical event. Thus, the tree describes the logical interdependency between the primary events (failures) resulting in the production of the top tree event.

It is important to understand that a failure tree is not a model which describes all possible system failures or all possible causes of its failure. A tree is built around a critical event depending on its particular failure mechanism, and the tree will contain only those events (failures) which contribute on making the tree top event possible. More, those defects are not exhaustive; they cover only the failures evaluated to be realistic by the analysts.

Also, it is also know that a fault tree is not by itself a quantitative model, but represents a qualitative model which can be evaluated even from a quantitative point of view.

The result of the failure tree is a binary event, i.e. either towards success or towards failure. The graphic model of the tree is compound from an entities' complex called “gates” which serve to allow or to deny the logic path towards the top event. The gates point to the necessary relations for producing a “superior” event. The symbol of a gate indicates the relation type between the input methods necessary for producing the output event.

In Figure 1 is represented an example of failure tree.

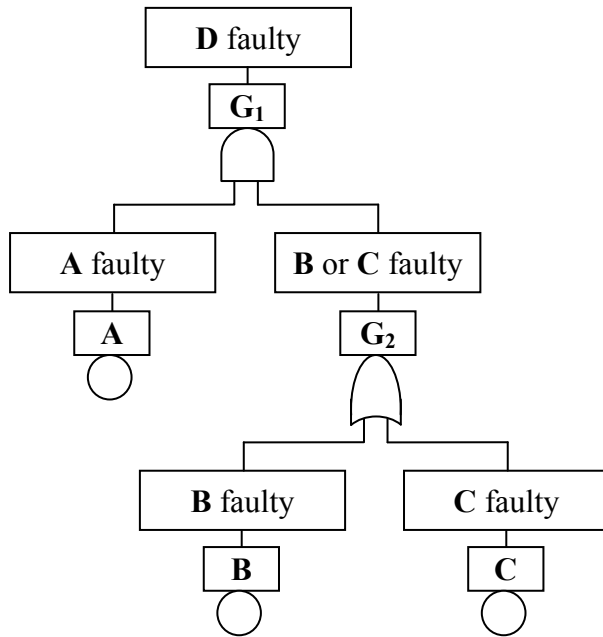


Fig. 1. Simplified example of failure tree

**2.1.1 Software failure tree analysis (SFTA)**

Software failure tree analysis technique represents a method of identification and documentation of inferior level software events which allows to an event on a superior level (root node) to manifest. If the root event is a critic one, the FTA technique helps the requests' defining process, describing the ways in which the system can reach that uncertain state [8].

To analyze the software reliability using the SFTA technique, first we must define the unwanted event as a root event. All the root events define the set of root events. Each root event has its own failure tree. Using logic relations between program modules we can analyze which modules or complex events (middle events) can cause the manifestation of the root event. The complex events analysis is continued until a stopping condition it reached, more exactly on a primary (failed) event. So, based on this analysis it can be represented the software failure tree.

A set of cuts represents a group of primary events (failures) whose manifestations lead to the falling of the system [11]. A set of cuts is called a minimal set of cuts only when they cannot be reduced and can cause the system failure. The minimal set of cuts provides a minimal set of successful events required to satisfy the root node. To obtain a set of min-

imal cuts, we use an algorithm "top-down", more precise the Fussell - Vesely algorithm [3]:

- 1) Down from the root event, events are listed taking in consideration the various logical relationships between them.
- 2) If the gate underneath the root node is an OR logical gate, input events are showed on different rows. Even if it is a logical gate the input events are showed on a single row.
- 3) Taking in consideration the complex event,  $G_i$ , it is also treated as a root event (same as the step 1) and the step 2 is repeated until the primary (failure) event it is reached.
- 4) Finally, a few sets of events are obtained representing all the cutting sets for the failure tree.
- 5) To obtain the minimal cut set from all those cuts obtained on 4<sup>th</sup> step the next operations are made: first of all the cuts are arranged depending of their number of events where every cut is been viewed as a product of primary events. Then the following relations are used to absorb the redundant cuts. Finally, the minimal cut set it's obtained.

$$A + A = A$$

$$A + A \cdot B = A$$

$$A \cdot A = A$$

Figure 2 shows the graph for obtaining all the minimal cuts form the failure tree from figure 1. Minimal cut set is composed from {A,B} and {A,C}

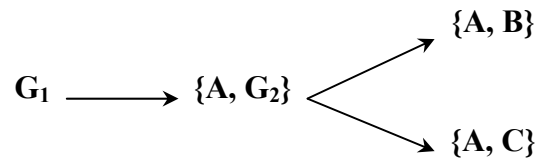


Fig. 2. Minimal Cuts Generation

It's been also showed that the SFTA technique can be realized on different levels and steps of the software developing process. The highest analyze level it's represented by the functional description. On the lowest level of

investigation, the SFTA technique analyzes the source code of the program. In this paper, it is used the SFTA methodology on the functional modules level, in order to analyze the reliability relations and the intrinsic requests of the system modules.

In this paper, taking in consideration a software system, the modules (components) are viewed as primary events, and the root node is associated with the system failure event. Then, resorting to SFTA technique, we can find out which are the important modules to which a higher reliability and security can be allocated, being more likely to lead the system to failure, if they are unreliable.

**2.1.2 Using the SFTA technique for software reliability allocation [7]**

It is consider  $P$  as being the maxim failure probability accepted and the software system is composed from  $n$  modules:  $m_1, m_2, \dots, m_n$ . Using the SFTA technique will obtain a number  $x$  of minimal cuts, after which the following algorithm is applied.

**Algorithm 1:** if a minimal cut contain a number of  $i$  modules, then the probability of failure of each module from the cut it's been given by the relation:

$$P_{m_j} \leq \left(\frac{P}{x}\right)^{1/i}, (j = 1, 2, \dots, n) \quad (1)$$

If there are intersections in the minimal cut set, the failure probabilities  $P_{m_j}$  can have  $k$  different values, noted with  $y_1, y_2, \dots, y_k$ . Case in which can define

$$P_{m_j} = \min(y_1, y_2, \dots, y_k) \quad (2)$$

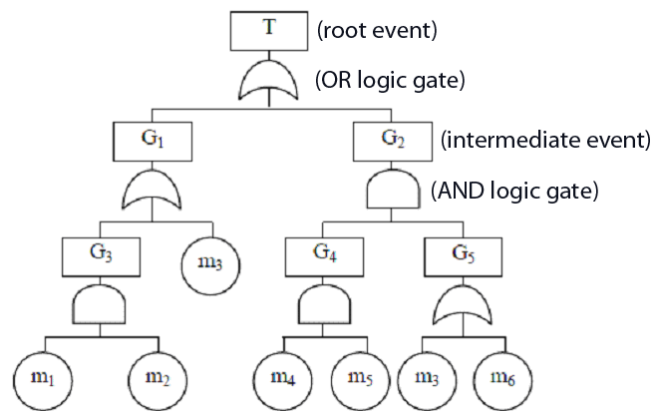
It must be mentioned that the algorithm use the geometric mean, in a certain way [7], the process being a reversed one regarding the classical analysis of system unavailability using SFTA [9,pp 619 - 627]. Using the classic method, by giving the failure probabilities to each module (data gather in the testing step), we can find out the failure probability of the entire system. The methodology used here,

represents the reversed method [7]: knowing the reliability request of the software system, from the planning or designing phase, the reliability of each module it's been investigated and determined, along with interdependency between modules.

According to the present algorithm, the probabilities  $P_{m_j}$  are obtained by applying the geometric mean which can have unimportant small errors. So, we can offer, to software engineers, a comprehensive understanding regarding the structure of the software system and the reliability request of each module; information which can help to determine the most important modules (key modules), allocating a higher reliability to the last ones.

**Example 1:**

For the practical explanation of the algorithm, the failure tree from Fig. 3 is examined for a software system made from six module  $m_1, m_2, \dots, m_6$ .



**Fig. 3.** An example of failure tree

The requirement is that the probability of the system failure to be  $P \leq 0,03$ . In which way the reliability must be allocated for each module?

Using Fussel-Veseley [3] algorithm, all the cuts are first obtained in Fig. 4, for the tree from fig. 3. So, the generated cuts are:

$$K_1 = \{m_3\}, \quad K_2 = \{m_1, m_2\}, \\ K_3 = \{m_3, m_4, m_5\} \text{ and } K_4 = \{m_4, m_5, m_6\}$$

But,  $m_3 = m_3 + m_3 \cdot m_4 \cdot m_5$ , with other words  $K_1$  it's subset from  $K_3$ , finally obtaining the minimal cuts:  $\{m_3\}$ ,  $\{m_1, m_2\}$ ,  $\{m_4, m_5, m_6\}$ .

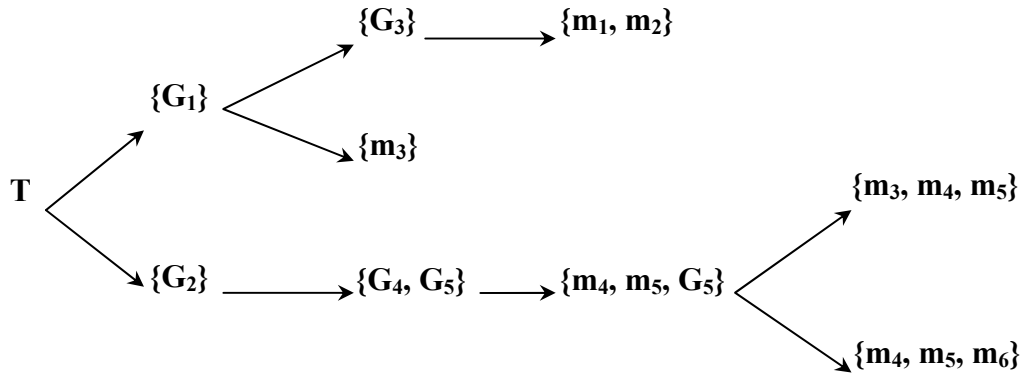


Fig. 4. Generating the minimal cuts for the tree from Figure 3

Then, applying the 1<sup>st</sup> relation, the following results are obtained:

$$P_{m_3} \leq \left(\frac{P}{3}\right)^{1/1} = 0,01 \tag{3}$$

$$P_{m_1} = P_{m_2} \leq \left(\frac{P}{3}\right)^{1/2} = 0,1 \tag{4}$$

$$P_{m_4} = P_{m_5} = P_{m_6} \leq \left(\frac{P}{3}\right)^{1/3} = 0,215 \tag{5}$$

In other words, the maximum failure probability of each module is:

(0.1, 0.1, 0.01, 0.215, 0.215, 0.215)

So that the reliability of modules must be

(0.9, 0.9, 0.99, 0.785, 0.785, 0.785).

Based on the minimal cut definition and the analysis made above can reach an important conclusion: if the number of modules from a cut is low, then for those modules the highest reliability must be allocated.

In example 1, because the number of modules from the minimal cut set follows the relation  $K1 < K2 < K3$ , the following conclusion is asserted:  $m_3$  is the key module, meaning that is the most important component from the system, thus must receive the most

reliability, and the  $m_4, m_5, m_6$  modules can receive a lower reliability than  $m_3$ .

### 2.2 Binary decision diagrams

The concept of binary decision diagram (BDD) was used, in the beginning, in the design and verification of VSSI (very large scale integration), as being an efficient method for the manipulation of Boolean expressions [14,9]. Bryant [2] and other researchers showed that, in most cases, the BDD technique use less memory to represent large Boolean expressions, instead of the common representation.

The binary decision diagrams are based on the Shannon decomposition, which makes the reliability evaluation to be accomplished very easy from the BDD form. A series of researchers successfully used this method in the reliability analysis of the failure trees [11, 15, 15 and 7].

The methodology presented in this papers it's based on the analysis of failure trees using binary decision diagram. Besides the technique already presented in the field's literature, the technique presented in this paper goes one step further, integrating this technology with the Java advanced programming techniques and technologies, used to automate the generation of failure trees and the generation of some reliability graphic indicators.

**2.2.1 Shannon Decomposition in ITE (If – Then - Else)**

Shannon decomposition theorem (or the developing theorem) is presented as following:

$f$  is a function that represents a Boolean expression defined on the  $X$  set, and  $x \in X$ . According with the theorem, the relation could be written as:

$$f = x \cdot f_{x=1} + \bar{x} \cdot f_{x=0} \tag{6}$$

where  $f$  is evaluated in  $x = v$  and get noted with  $f_{x=v}$ .

Shannon decomposition is behind the use of binary decision diagram. To precise describe this theorem, it's defined as If-Then-Else (ITE) as following:

$$f = ite(x, F_1, F_2) = x \cdot F_1 + \bar{x} \cdot F_2 \tag{7}$$

where  $F_1 = f_{x=1}$  and  $F_2 = f_{x=0}$ .

A BDD diagram represents a directed acyclic graph which has the Shannon decomposition at its base. The graph has a single root node and two terminal node, noted with 0 and 1, representing the two constant expressions. Each complex node is noted with a  $x$  boolean variable and has two exit branches. These two branches are called 0-branch (*else* branch) and 1-branch (*then* branch). The node connected with the 1-branch represents a boolean expression when  $x = 1$ , i.e.,  $f_{x=1}$  from the equation (6), while any node connected to a 0-branch indicates a Boolean expressions when  $x = 0$ , meaning  $f_{x=0}$  in equation 6. In fact, each complex node from BDD encrypts if-the-else instructions.

An ordered binary decision diagram (OBDD) follows the rule through which the variables (nodes) are ordered, and the chart depth crossing is done in an ascending order following the nodes order. An reduced and ordered binary decision diagram (ROBDD) is a OBDD diagram in which each node represents a different boolean expression.

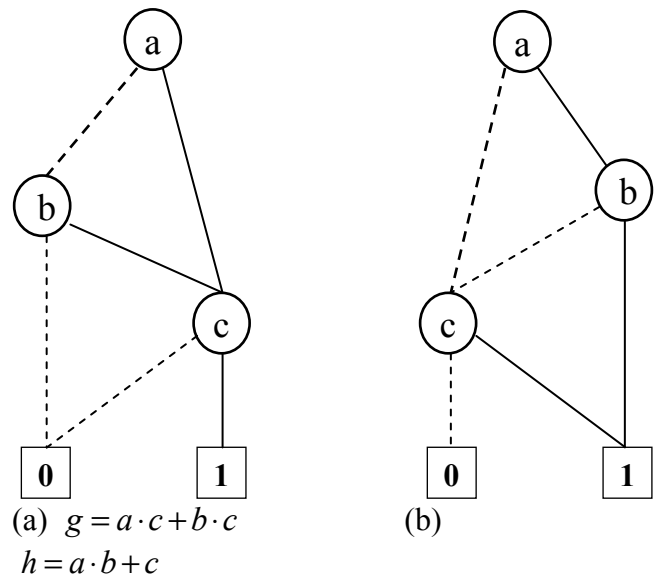
In practice, ROBDD diagrams are often used. To be able to generate a ROBDD diagram, first we must ordonate the variables, and this order must remain the same during the diagram generation process. In this paper, we note with  $x_i < x_j$  in case in which the  $x_j$  variable is behind the  $x_i$  variable, in the ordered node list.

Figure 5, describes two examples of ROBDD diagram generated for two different boolean expression.

Applying the equation (7), the *ite* forms of the  $g$  and  $h$  expressions are:

$$g = ite(x, g_{x=1}, g_{x=0}) = ite(x, G_1, G_2) \tag{8}$$

$$h = ite(x, h_{x=1}, h_{x=0}) = ite(x, H_1, H_2) \tag{9}$$



**Fig. 5.** BDD examples for two Boolean expressions

In practice it's been shown that the BDD are generated using rather logical operations on the variables instead of applying directly the Shannon development.

**2.3 Quantitative Analysis**

Quantitative analysis is performed on the binary decision diagram (BDD) [12] representing an exact and efficient method allowing us to determine many reliability characteristics of a hardware/software system.

Furthermore we will refer to methods which use the BDD's containing complex or/and

modular events. The analysis purpose [2] is that to obtain probability of the critic event and the intensity of unconditioned failure.

### 2.3.1 System Unavailability

The probability of the critical events manifestation, noted with  $Q_{sys}$  it's obtained through the sum of probabilities obtained on disjoint branches from crossing the primary BDD diagram. An algorithm of depth crossing (depth first) can effectively perform this calculation; in paper [15] an elaborate description of this method is presented.

To make this calculation we need to know the unavailability of each coded event. For this, the probability of complex events and of modular ones must be obtained from the primary events data obtained experimental.

The determination of unavailability complex events is straightforward, these events being a combination of two component events. The calculation depends on how events are combined, under a "AND" logic gate or under a "OR" gate, thus, if  $x_c$  is a complex event and its constituent events are  $x_1$  and  $x_2$ , then following will exists:

$$\text{logic gate "AND"} : q_c = q_1 \cdot q_2 \quad (10)$$

$$\text{logic gate "OR"}: q_c = q_1 + q_2 - q_1 \cdot q_2 \quad (11)$$

where:  $q_c$  is the probability of achieving the complex event, and  $q_1$  and  $q_2$  are the probabilities of realization of  $x_1$  and  $x_2$  events.

The probabilities of complex events are calculated according to their construction, making the process more efficient.

The calculation of modular events probabilities it's made by determining the probabilities of the "top tree event" manifestation for each separate module. Also, in this case depth crossing algorithm is used. Thereby, first the unavailability of those modules must

be evaluated, which encrypts only the primary and complex events.

After the probabilities of the complex events were obtained along with those of the modular ones, the system unavailability can be easily determined.

### 2.3.2 Unconditioned Failure Intensity of the System

Unconditioned failure intensity of the system (called the system failure frequency)  $W_{sys}(t)$ , is defined as the probability with which the critic event (root node) manifest itself at the  $t$  moment and it's calculate using the following relation:

$$w_{sys}(t) = \sum_i G_i(q(t)) \cdot w_i(t) \quad (12)$$

where  $G_i(q(t))$  it's the critically function (or the risk function associated to each failure node) for each component, and  $w_i(t)$  represents the unconditioned failure intensity of one component.

Explicitly, the risk function is defined as the system probability to be in a critical state, in relation with the component  $i$  and, so, failure of this component would make the system to pass from a functionality state to a failure one. So, it's result the relation:

$$G_i(q(t)) = Q(1_i, q(t)) - Q(0_i, q(t)) \quad (13)$$

where:  $Q(1_i, q(t))$  is the probability of system failure with  $q_i(t)=1$ , and  $Q(0_i, q(t))$  is the probability of system failure with  $q_i(t)=0$ .

An efficient method for calculating criticality takes in consideration the probability of diagram branches before and after the respective nodes, leading to the following expression:

$$G_i(q(t)) = \sum_n pr_{x_i}(q(t)) \cdot [po_{x_i}^1(q(t)) - po_{x_i}^0(q(t))] \quad (14)$$

where:  $pr_{x_i}(q(t))$  - is the branch probability which leaves from the root node towards the  $x_i$  node,  $po_{x_i}^1(q(t))$  - the path probability on

branch '1' of the node  $x_i$  towards terminal node 1,

$po_{x_i}^0(q(t))$  - the path probability on branch '0' of node  $x_i$  towards the terminal node 1, and

$n$  - all nodes corresponding to variable  $x_i$  from DDB.

For a single BDD, which codes only the primary events is necessary a single crossing of diagram in order to calculate  $pr_{x_i}(q)$ ,  $po_{x_i}^1(q)$

and  $po_{x_i}^0(q)$  for each node, from where it can be obtained the risk function of each primary event, leading to the unconditioned failure intensity evaluation of the system.

However, this method doesn't take in consideration the modular and complex events. It is possible the calculation of  $W_{sys}$  taking in consideration only the primary events coded in the primary diagram, but this presumes the knowledge of both the risk of modular and complex events and the intensities of unconditioned failures. Even if these are not hard to gather, they represent some values which don't present any utility in the performed analysis. Rather than those the risk functions of the primary events will be calculated which will be used together with their unconditioned failures intensities to determine  $W_{sys}$ .

These risk functions of primary events, from the primary BDD diagram, can be also calculated while obtaining the path probabilities for the primary diagram nodes.

### 3 Using Java Language in Software Reliability Analysis

Within the methodology for integration of more reliability techniques in a global framework it's been included a Java library, with the help of which it can be generated a binary decision diagram (BDD) and different

reliability indicators can be evaluated for a considered software system

*JReliability* represents a library written in Java programming language which has as purpose the reliability evaluation of a system and have been developed in the Hardware/Software Co-Design Department of the Computer Science Faculty from Erlangen-Nuremberg University from Germany, [18]. The library is adapted (but not limited to) modeling and analysis based on BDD of complex systems, such us network integrated systems. Till now various materials have been published at internationals conferences, researches based on analysis and modeling for this library [4, 9, 11].

This paper extends the *JReliability* library utilization in order to analyze the system software reliability.

*JReliability* library is based on previous developed libraries, such as: JavaBDD - a Java library for binary decision diagram manipulation; Ptolemy Plot (java library for plotters).

*JReliability* allows gathering reliability indicators, such as MTTF, or mission time (MT) of complex systems which are used using Boolean functions, efficient represented through binary decision diagrams.

The library is very extensible so various special evaluators for gathering others reliability indicators can be included along with designing other system representation.

More, *JReliability* offers a graphic user interface (GUI) to visualize the obtained reliability indicators, also the possibility to view the Boolean representation of the system (the BDD), using DOT graphic language. Figure 6 presents the result of reliability evaluation for the failure – tolerant structure of TMR (Triple-Modular-Redundancy) type.



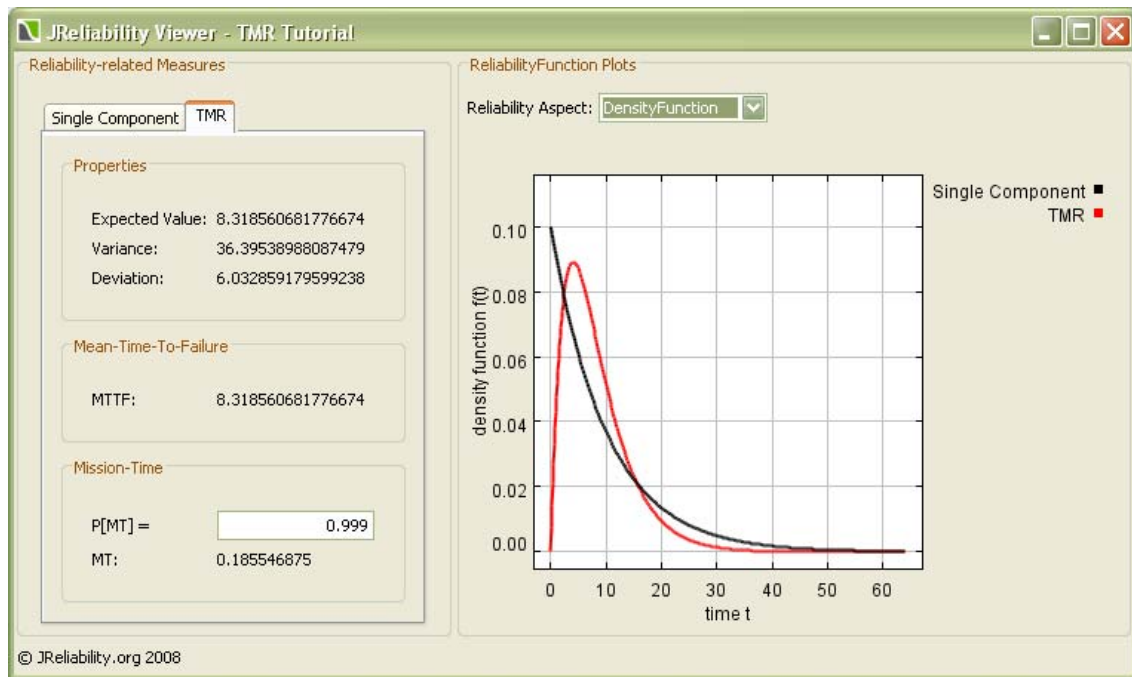


Fig. 6. Analysis of the TMR reliability structure using *JReliability*

### 3.1 Operation of *JReliability*

The idea which underlines the use of *JReliability* library is that there is a Model of the system which describes the system behavior in the case of failure manifestation, failures or repairs of the system component. Having this Model it can generate the overall *Reliability Function*. In the last step, a set of evaluators will obtain reliability indicators, based on the Model and *Reliability Function* or, if possible, only on the *Reliability Function*. The principle is schematically described in Figure 7.

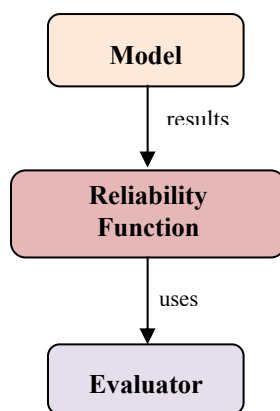


Fig. 7. Functional principle of *JReliability*

### 3.2 Reliability Modeling with *JReliability*

The behavior of a system (failure mechanism) is usually represented by failure trees,

reliability block diagrams (RBD), automated, Markov chains or Boolean functions. All of these techniques have in common the fact that they exist, implicitly or explicitly, a data structure which can observe if the system function properly, to a certain point, or if it is unavailable, i.e. doesn't work properly.

*JReliability* uses a Boolean function to represent system structural function; function encrypted with binary decision diagrams (BDDs)

To obtain the *Reliability Function* of the whole system, it must be known the *Reliability Function* of each component from the system. For this purpose, *JReliability* is using a data structure called *Transformer Function*, which represents mapping of each element (component) corresponding to his own *Reliability Function*. *JReliability* comes with a wide set of *Reliability Function* known and predefined, based on exponential distributions, Weibull distributions and many others. Having this knowledge, *JReliability* structure can be refined like in the Figure 8.

Note that the BDD which encrypts the Boolean functions combined with the *Transformer Function* represents an approach to obtain the global *Reliability Function*. The user can implement other methods which will lead to expanding the use of *JReliability* library.

### 3.3 Reliability Evaluation

Once the global *Reliability Function* of the system has been obtained, it can evaluate different reliability indicators such as: average lifetime until the failure – MTTF, mission timing – MT, failure rate, etc., using the so called *Evaluators*. An evaluator receives from input a *Reliability Function* and evaluates the wanted indicator either analytically, either by gathering evidence or simulating.

Some Evaluators require, also, the access to *Reliability Function* of each component from the system and to structure Boolean functions of whole system, encrypted in BDD. To reach this purpose, was developed a special *Reliability Function*, called *BDD Reliability Function*, which offers the access to *Reliability Function* of each component, and to whole BDD.

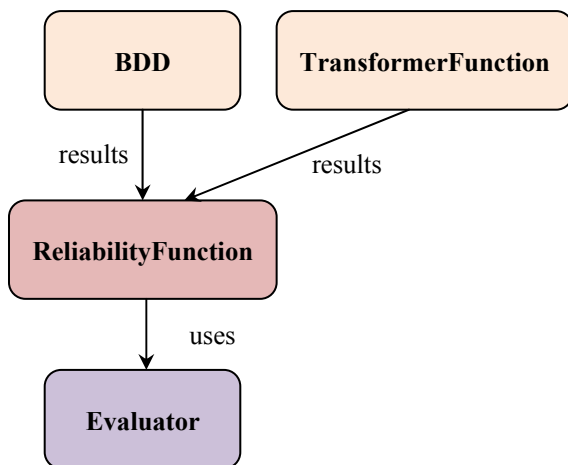


Fig. 8. *JReliability* extended structure  $Model = \{BDD, TransformerFunction\}$

### 3.4. Binary decision diagrams role in *JReliability*

The basic model of system behavior, current in *JReliability*, is the Boolean function. Data structure used to efficiently encrypt this kind of functions in *JReliability* is given by binary decision diagrams. An important characteristic of the *JReliability* library is that it offers a generic special interface for a series of BDD libraries, which allows directly using BDD variables of Java objects to model components of the real system.

BDD allows canonical representation of Boolean functions. BDD represents an acyclic di-

rection graph with root and is made from decision nodes, which corresponds to variables and two terminal nodes, 0 and 1, which corresponds to returned value of Boolean function. Since each is a binary variable which can make only 0 and 1 value, each decision node presents two output ramifications, low and high, corresponding to the case in which the variable takes 0 and 1 values. This process is presented in fig. 9. Any values attribution for variables which lead to terminal node 1 corresponds to a functional system, while any attribution of values for variables which lead to terminal node 0, corresponding to a system in a failure state.

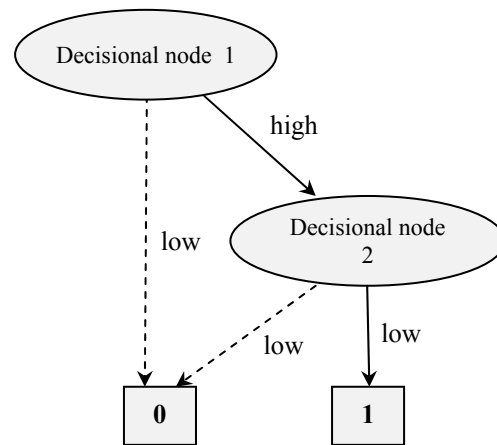


Fig. 9. BDD data tip structure example

In this reliability library, each variable corresponds to one component, being represented by a Java object. Value 0 corresponds to a failed component and value 1 to a component in a good state of functionality. Objects which model the components are directly connected between them by logic operators, AND or OR, with which all structure functions are encrypted in a single BDD.

### 4 Conclusions

SFTA technique used for allocation software reliability is a clear, simple and efficient. It can be used not only at the level of system analysis, but also at modules and subsystem analysis level.

Because the construction process of failure tree offers a comprehensive understanding of the system, it's been asked from the software engineer a better control of relations between

the modules, to remove any factor with an unsafely potential, so the result of reliability to be more rational.

More, SFTA represents a deductive graphic method, describing in a clear way the relations from the system framework, what makes easy the identification process of key modules, with the purpose of reliability allocation.

This paper introduces a new integrated framework for software reliability analysis, using analysis and modeling techniques:

- software failure tree method, SFTA;
- binary decision diagram, BDD, for the SFTA analysis;
- Java evaluation techniques for Java reliability, *JReliability*

With the help of Java library, *JReliability*, we could automate the generation of binary decision diagram for a considered system, after applying the SFTA technique. The new methodology is simple, efficient, having a considerable development factor, limited only at software engineer knowledge level which analyzes the systems reliability.

Other analysis and modeling approaches (Markov model, simulation models) are necessary for the cases in which a system failure depends even by the order in which the events (errors) appears, and not only by their simple combination.

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