A HIERARCHIAL METHOD TO DERIVE MINIMAL CUT SETS DIRECTLY FROM A FAULT TREE

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Abstract

In this paper , a hierarchical procedure to derive a minimal cut sets from fault tree's is presented Since for more complicated fault trees it will not to be possible to determine the cut sets by observation so a more structured method- will be necessary. The presented method is a modification of the method in[5], it is illustrated through two examples for different size of fault tree's. Conclusions are drawn at the end .

1. Introduction

There are several methods by which a minimal cut sets can be determined . Some of them based on prior knowledge of graph theory and Boolean algebra while others depend on set theory and probability ...etc . See [1], [3],[4] .

The method in question uses the logical gates AND and OR to develop the minimal cut sets from a fault tree directly, involves numbering each gate and event in the fault tree with the fact that each input to an OR gate identifies a separate cut set and that every AND gate identifies just one cut set.

2. Some Definitions and Concepts:

Definition (1) : Fault Tree

A fault tree is a diagrammatv; representation of all possible fault events , their logical combinations , and their relation snip to the system failure .

Definition (2) : Basic Event

A basic event is a basic initiating fault event that requires no further development .It is symbolized by circle .

Definition (3) : Intermediate Event

An intermediate event is a fault event which occurs because of one or more antecedent causes acting through logic gates . All intermediate events are symbolized by rectangles .

Definition (4) : Minimal Cut Set

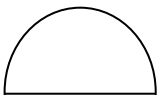
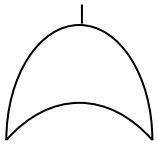
A minimal cut set can be difined as the smallest uneducable collection of basic events required to insure occurrence of top event i.e, (the system failure) A fault tree will consist of a finite number of minimal cut sets .

There are two basic types of fault tree gates:

1- The OR gate which is used to show that the output event occurs only if one or more of the input events occur.

2- The AND gate which is used to show that the output fault occurs only if all the input faults occur.

The symbols of AND and OR gates are shown in the following figure respectively . For more detail see [2] , [5]

(a) AND gate  (b) OR gate Fig. (1) Shows us AND and OR gates 

3-The method

After numbering each gate and basic events start with the tollp gate on the fault tree .The method consists of a stagewise vertical listing of abasic failure events and gates of the next lower state leading to the failure event at the stage under consideration .Then we hierachially work our way down until we reach all the basic or primary events of the considered system .

4- Illustrative Examples

To illustrate the method above , consider the two following examples

Example (1):-

Consider the fault tree shown in figure(2). To derive the cut sets , the steps are as follows :

The first step was to list vertically all the basic events and gates leading to the first level OR gate G1. In the second step we expand second level gates G2 and G3 by vertically listing all basic events or third level gates leading to them . Wherever an AND gate is met , basic events and gates leading to it are listed horizontally as shown in the table below . Essentially what we have done is to sequentially or hierarchially replace each gate by its input basic events or gals until all fault tree gates are replaced with the basic event entries . The final minimal cut set listed under step 3 consists of events 1,2,7,and 8 and joint events 3 ,4 and 5,6.

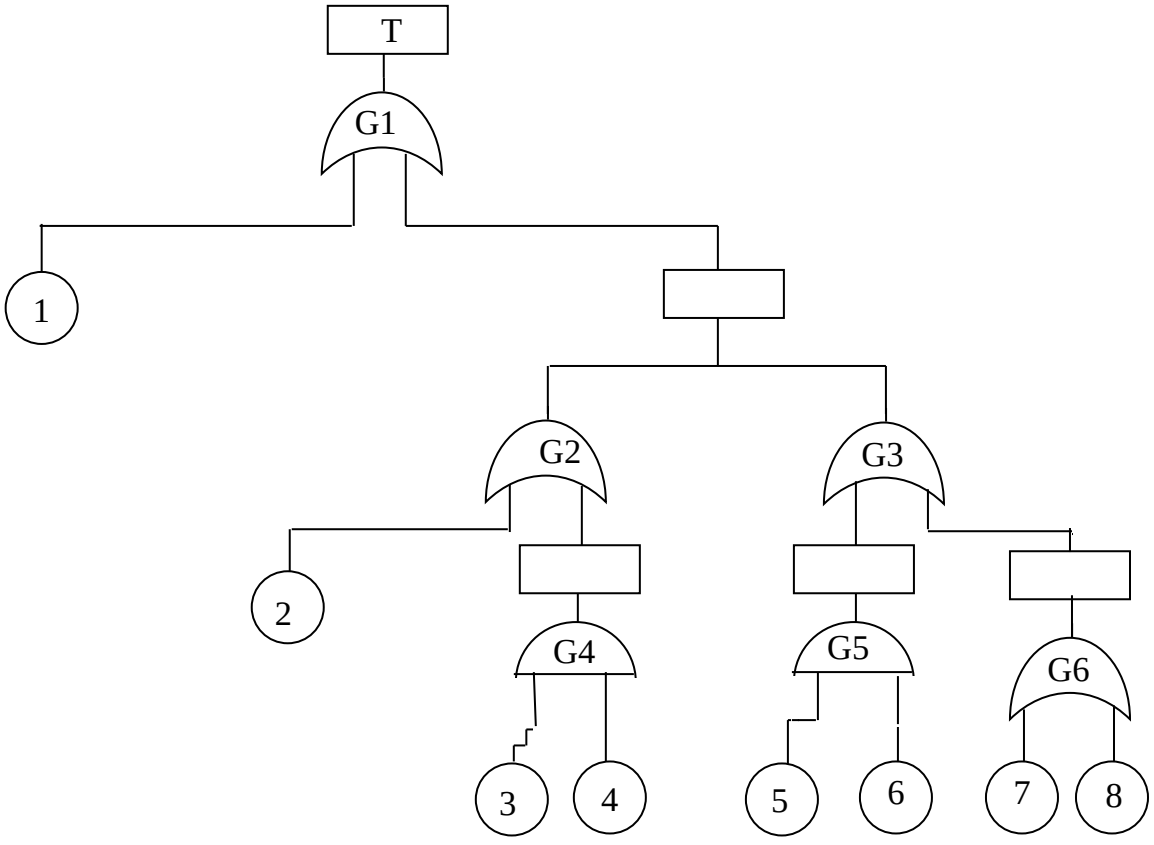


Fig. (2) F T of example (1)

Step 1	Step2	step3
1	1	1
G2	2	2

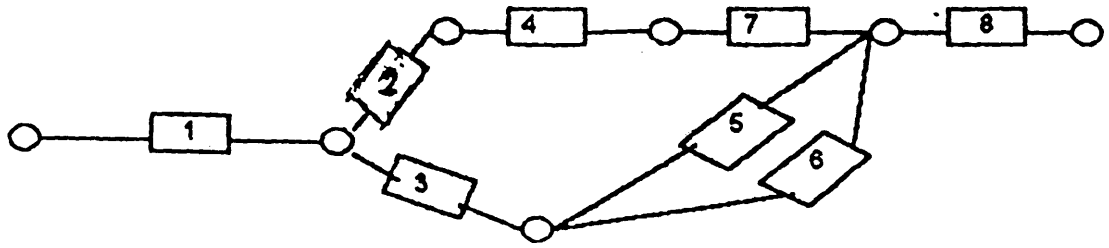


Fig . (3) A system Network

The corresponding fault tree if the system above is shown in fig . (4) below .

	G4	3,4
G3	G5	5,6
	G6	7 8

Table (1)

If in a cut set in which all gates have been eliminated a basic event is both a member of the cut set as a single event as well as part from the cut set to derive the minimal cut set . In other words, a single event is a "more" basic event that a joint event made up of such single events .

Example (2) :

Consider a system which consists of eight components , as shown in the following network .

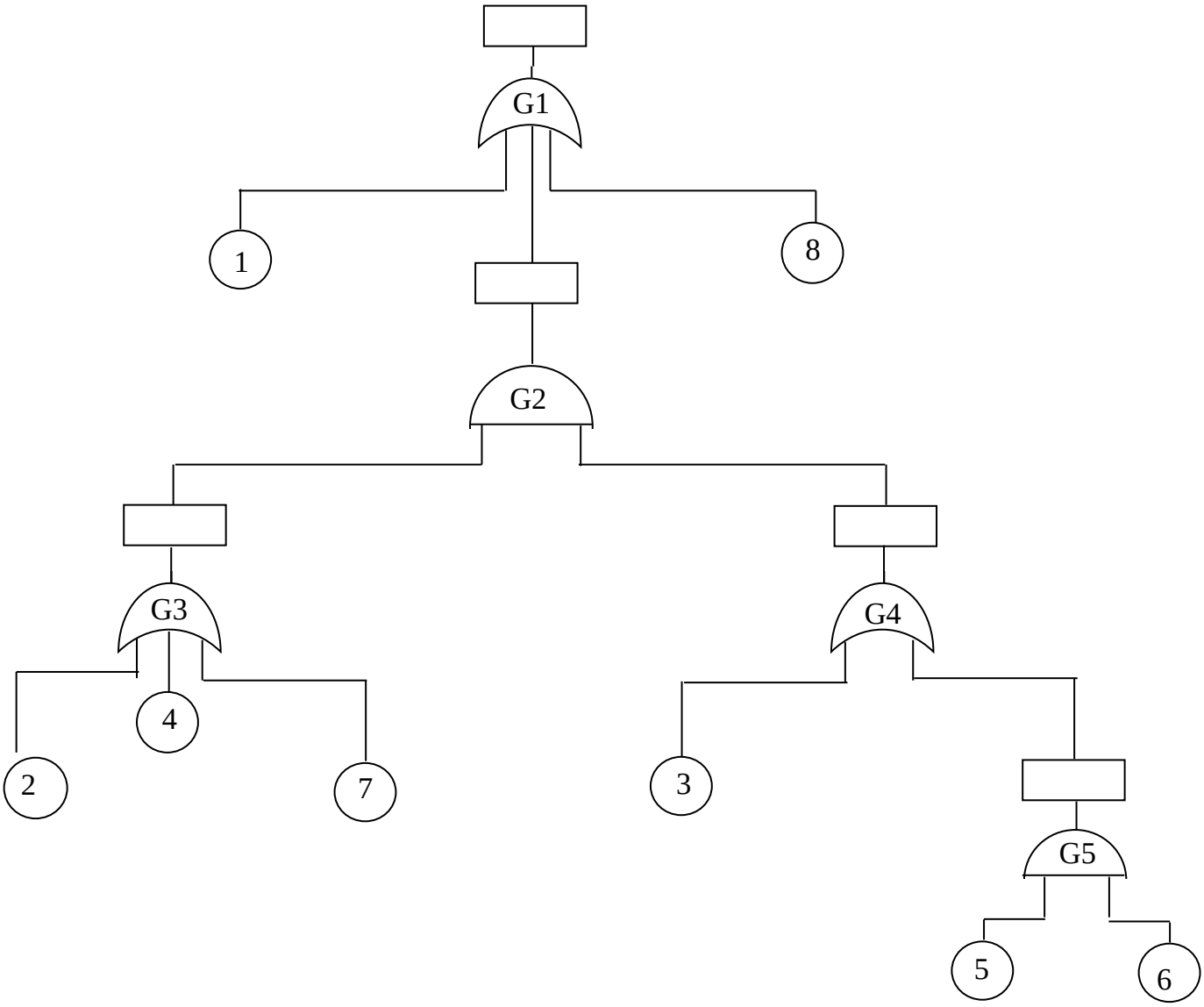


Fig . (4) A fault tree of Fig . (3)

The top gate G1 is an OR gate with three inputs . In step (1) , we list vertically all basic events and gates 1 , 8 and G2 .

In the second step we replace G2 by its input , G3 G4 horizontally . leading to the first level. In the next step we expand gates G3 , G4 by vertically listing all primary events or gates leading to them.

In step(4) we replace gate G5 horizontally by its basic events 5,6.Now all of the gates have been replaced by their inputs , so in the last step we list all the minimal cut sets i.e it consists of events l , 8 and joint events (2,3) , (4,3) , (7,3) , (2.5,6) , (4.5 , 6) , (7.5, 6) as shown in the table below .

Step 1	Step 2	Step 3	Step 4	Step 5
1	1	1	1	1

G2	G3 , G4	2 3 4 , G5 7	2 , 3 4 , 5 , 6 7	2 , 3 4 , 3 7 , 3 2 , 5 , 6 4 , 5 , 6 7 , 5 , 6
8	8	8	8	8

Table (2)

5- Conclusions

1 - An OR gate always increase the number of cut sets (There will be a separate cut set for each OR gate input).

2- An AND gate always increase the size of a cut set (There Will be one cut set for an AND gate, and each input increase the size of the cut set) .

3-The presented method can be used : -

a. To obtain the cut sets for any size fault tree, since it will not to be possible to derive the cut set by observation for more complicated fault trees .

b . For both manual and computer analysis of fault trees .

4-It is simpler than the algebraic. reduction method which presented in [5] because the later requires to translate the especially for large size of fault trees, fault tree to its equivalent Boolean equation and thus it saves time especially for large size of fault trees.

References:

[1] Balagursumy , E . (1984). Reliability Engineering .Tata Mc. Grow-Hill publish company limited .

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[3] Ross , S . (1969) . Introduction to Probability Models. Naval Research Logistics Quarterly .

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