5) Fault Tree Analysis

FOSSEE (R Team)

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Fault Tree Analysis (FTA)

What is Fault Tree Analysis (FTA)?

The interrelationships between critical events of a system and their causes can be visualized using a top-down logical diagram known as the **Fault Tree Analysis** or **FTA.** FTA is a graphical-mathematical tool, and it is used to identify potential causes of system-level failures before they occur. FTA uses symbols to describe events and connections; therefore, it is referred to as a graphical tool. It is extensively used in reliability and safety studies.

What are the elements of a Fault Tree?

Following are the main elements of a Fault Tree -

- **Top Event** - This is the event of interest. The whole Fault Tree is developed under this event.
- **Intermediate Event** - Event which lies in between the Top and Basic events
- **Basic Event** - Fundamental event which cannot be further developed
- **Logic Gates** - Establish relationships between output event and the corresponding inputs

The top event is connected to basic events via different intermediate events with the help of logic gates.

What are the symbols used in FTA?

There are two types of symbols which are used in FTA -

- **Event Symbols** - Symbols representing a particular event.
- **Gate Symbols** - Symbols representing logic gates which are used to connect individual events.

Following tables give a description of all symbols used in FTA -

Table 1: Event Symbols

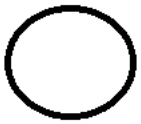
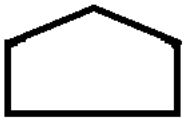
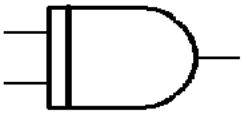
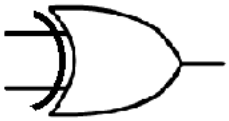
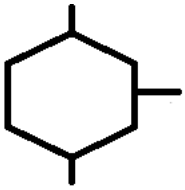
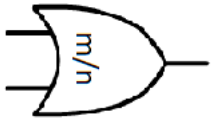
S.No.	Symbol Name	Event Symbol	Description
1	Circle		Primary or Basic Failure Event
2	Rectangle		State of system or subsystem
3	Diamond		Secondary Failure or Under Developed Event
4	Oval		Conditional Event
5	House		House Event
6	Triangle		Transfer-in and transfer-out symbols

Table 2: Gate Symbols

S.No.	Symbol Name	Gate Symbol	Description
1	AND		True if all input events occur

S.No.	Symbol Name	Gate Symbol	Description
2	OR		True if at least one input event occurs
3	Priority AND		True if all input events occur from left to right
4	Exclusive OR		True if only either of the input events occurs
5	Inhibit		True if attached condition & input events occur
6	m/n		True if m-out-of-n input events occur

What are the parameters associated with FTA?

Following are the parameters associated with FTA -

- **MTTF** - The mean time to failure
- **MTTR** - The mean time to repair (restore)
- **Inspect** or τ - The time interval between inspections for the dormant component
- **Failure Rate** or λ
- $\mathbf{P_o}$ - Basic event probability (λ * MTTR)
- **Prob** - Probability of failure (1-((1-exp(-τ/MTTF))/(τ/MTTF)) * (1-P_o))

Introduction

The purpose of this experiment is to perform a **Fault Tree Analysis** or **FTA** of a hypothetical situation. For the sake of simplicity, a situation of internet connection failure is chosen for FTA, but any other situation can be analyzed similarly.

Procedure

Step by step procedure to conduct the required experiment -

1. Creating top event
2. Creating intermediate events
3. Creating basic events
4. Performing fault tree calculation
5. Creating fault tree tabular subview
6. Displaying fault tree in browser

Note : Please make sure that the following package is already installed -

- FaultTree

Code and Results

```
## R has a predefined package with the name "FaultTree" for performing FTA
 # To know more about the package, after loading it using the "library" command, type
 # "?FaultTree" in the console
```

Creating top event

```
# 1) Creating top event
# Run the following command after removing "#" if "FaultTree" package is not installed
# install.packages("FaultTree")
  library(FaultTree)
  Fault_Tree <- ftree.make(type="or",reversible_cond=TRUE, name="Internet Connection",
  name2="Failure")
```

Creating intermediate events

```
# 2) Creating intermediate events
  Fault_Tree <- addLogic(Fault_Tree, at=1, type="or", name="Hardware Issue")
  Fault_Tree <- addLogic(Fault_Tree, at=1, type="or", name="Software Issue")
```

Creating basic events

```
# 3) Creating basic events
  Fault_Tree <- addLatent(Fault_Tree, at=2, mttf=1.5,mttr=2,inspect=0.87,
  name="Router Malfunctioning")
  Fault_Tree <- addLatent(Fault_Tree, at=2, mttf=1.5,mttr=2,inspect=0.5,
  name="Power Supply is OFF")
  Fault_Tree <- addLatent(Fault_Tree, at=3, mttf=1.5,mttr=2,inspect=0.33,
  name="Change in Network", name2="and Internet settings")
  Fault_Tree <- addLatent(Fault_Tree, at=3, mttf=1.5,mttr=2,inspect=0.72,
  name="Driver not installed")
```

Performing fault tree calculation

```
# 4) Performing fault tree calculation
  Fault_Tree <- ftree.calc(Fault_Tree)
```

Creating fault tree tabular subview

```
# 5) Creating fault tree tabular subview
  ftree2table(Fault_Tree)
```

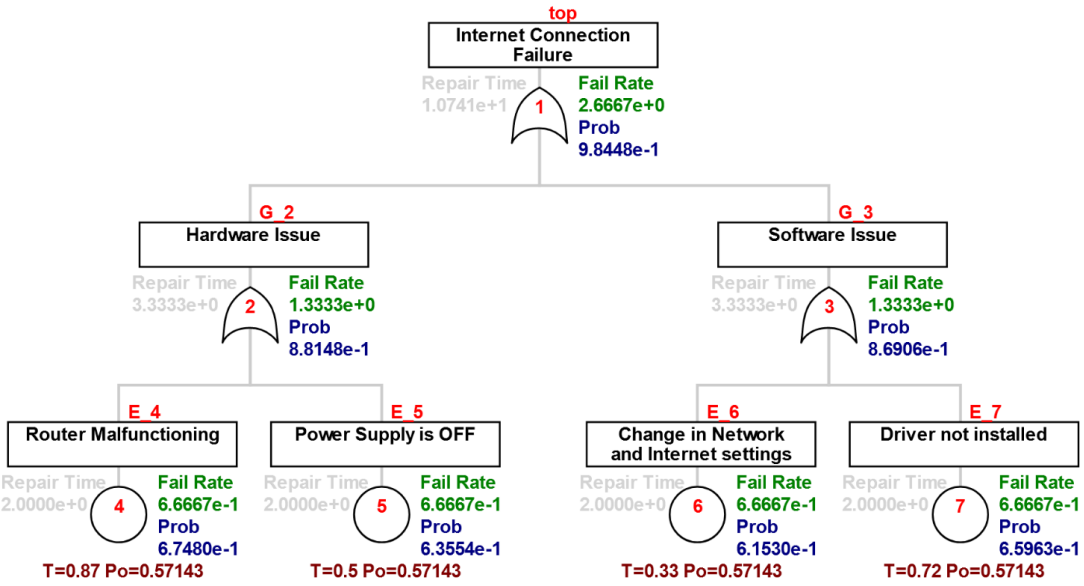
```
##   ID Parent       CFR       PBF       CRT MOE Cond Label                  Name
## 1  1     -1 2.6666667 0.9844805 10.740741   0    0         Internet Connection
## 2  2      1 1.3333333 0.8814783  3.333333   0    0             Hardware Issue
## 3  3      1 1.3333333 0.8690577  3.333333   0    0             Software Issue
## 4  4      2 0.6666667 0.6748017  2.000000   0    0       Router Malfunctioning
## 5  5      2 0.6666667 0.6355403  2.000000   0    0         Power Supply is OFF
## 6  6      3 0.6666667 0.6152964  2.000000   0    0           Change in Network
## 7  7      3 0.6666667 0.6596280  2.000000   0    0        Driver not installed
```

Displaying fault tree in browser

```
# 6) Displaying fault tree in browser
  ftree2html(Fault_Tree, write_file=TRUE)
```

```
##   ID Parent       CFR       PBF       CRT MOE Cond Label                  Name
## 1  1     -1 2.6666667 0.9844805 10.740741   0    0         Internet Connection
## 2  2      1 1.3333333 0.8814783  3.333333   0    0             Hardware Issue
## 3  3      1 1.3333333 0.8690577  3.333333   0    0             Software Issue
## 4  4      2 0.6666667 0.6748017  2.000000   0    0       Router Malfunctioning
## 5  5      2 0.6666667 0.6355403  2.000000   0    0         Power Supply is OFF
## 6  6      3 0.6666667 0.6152964  2.000000   0    0           Change in Network
## 7  7      3 0.6666667 0.6596280  2.000000   0    0        Driver not installed
```

```
  browseURL('Fault_Tree.html')
# Below is a screenshot of the fault tree as displayed in a browser
```



Conclusion

Fault Tree Analysis (FTA) of the internet connection failure situation has been successfully performed.