ABSTRACT

The objective of this research paper is to discuss the Network reliability as a problem in Network engineering. It starts with the introduction of Network reliability and defines the Network reliability. The solution of this problem leads to the new approach of Network development known as Network Reliability Engineering. It then discuss about the difference between Classical & Modern Approach of Network Development with respect to Network reliability & briefly discusses about the feasibility of Network reliability engineering.

It then discusses about the Network Reliability Engineering process briefly. It describes the classification of Network reliability models & the indirect measures used by them to measure the reliability of Network system i.e. Network Reliability Metrics. It then discusses the important issues or problems related to Network reliability evaluation.

Abbreviations

S.R.E : Network Reliability Engineering
C.B.S.E. : Component Based Network engineering

I. Introduction

Now a day generally systems are Network-based systems. The objective of the system is to satisfy the users of the system. Here definition of users of the systems is very broad i.e. they can be a single user, an organization (business / government). To satisfy these users; the system should be quality one. Quality of the system depends upon the quality of Network subsystem. Quality of the Network system is directly related with reliability characteristic of the Network system. As the Network development is competitive one, the company has to make the balance in between reliability, delivery date & cost of the development. In the next section we will be discussing about the meaning of Network Reliability.

II. What is Network Reliability?

Network Reliability is user oriented rather than developer oriented. It relates to operation rather than design of the program & hence it is dynamic in nature rather than static. It depends upon the frequency of the problem occurrence & the experience on that problem solution. Hence it directly relates with the costs also.

According to ANSI / IEEE (1), “Network Reliability is defined as the probability of failure free Network operation of a specified period of time in a specified environment.”

III. Difference between Classical & Modern Approach of Network Development With Respect To Network Reliability

Under classical approach of Network development; the Network developers has given the more attention to quantifying the delivery time & cost of the Network product. It means that Network reliability will suffer when the Network developers will compete for attention against schedule & cost. The result is less reliable Network product i.e. angry users. Thus modern approach of Network development was developed to resolve this problem by quantifying the Network reliability. This approach is called as the Network Reliability Engineering By engineering the Network reliability means developing the product in such a manner that it maintains the balance in between reliability, delivery time & cost of the developed product [2].

According to IEEE, charter & Organization of the Network Reliability Engineering Committee, “S.R.E. is the quantitative study of the operational behaviour of Network – based systems with respect to user requirements concerning reliability.”[3]

IV. Feasibility Study of the S.R.E.

According to empirical study of the developed Network products using S.R.E., the cost of development has been reduced to a measurable level [2]. It improves the productivity of the Network products & also reduced the risk of unsatisfied users. We can compute the operating cost of S.R.E. over the product life cycle as a percentage of product Network development cost as follows:

\[ P = 10 \times S \times 0.74 \]
Where P is the percent & S is the product size in staff years. The operating cost of applying S.R.E is not that much high.

V. Network Reliability Engineering Process:
Network Reliability Engineering integrates activities related to it with the conventional development processes. It supports the Evolutionary Approach of Network Development [2]. It consists of six activities listed & discussed as follows:

- **Defining the Product:** It includes who the supplier, customers & users are.
- **Implementing Operational Profiles:** An operational profile is a complete set of operations with their probabilities of occurrence. We will both develop operational profile & apply them.
- **Engineering the “Just Right Reliability”:**
  The quantitative definition of reliability makes the balance in between user needs for reliability, delivery time & the cost. The quantitative measure of reliability depends upon the testing.
- **Preparing for Test:** It involves the new test cases for the modified operational profiles.
- **Executing Test:** During this activity based on the reliability measure we allocate test time & execute the tests for finding the failures.
- **Guiding Test:** After getting the failure data; we process it to find the failure intensity to describe Network reliability.

VI. Network Reliability Models:
These models are used to measure the product required for a Network product. The complexity of the Network is inversely related to Network reliability [4]. These models have their limitations imposed by complexity of the Network & the environment. Therefore there is no single model that can be used in all situations.

All these Network models contains assumptions, factors & a mathematical function that relates the reliability with the factors & Network modeling techniques can be divided into two sub categories:

- Prediction Modeling
- Estimation Modeling

These techniques are based on observing & collecting failure data & analyzing with statistical inference. Using prediction models, Network reliability can be predicted early in the development phase & enhancements can be imitated to improve reliability.

Using estimation models; Network reliability can be estimated for the developed Network systems.

VII. Network Reliability Metrics:
Network Reliability cannot be measured directly. Indirect Measures will be used to measure the Network reliability [4]. These measures are of four categories:

- Product Metrics
- Project Management Metrics
- Process Metrics
- Fault & Failure Metrics.

VIII. Issues in Network Reliability Evaluation:
As already discussed that Network Reliability Engineering is the quantitative study of the operational behaviour of Network based systems with respect to user requirements concerning reliability. It includes the evaluation of Network Reliability throughout the life cycle of Network development. It introduces the new issues such as how to specify the requirements in the analysis phase of the Network engineering etc.

Network Reliability is defined as a probabilistic function of time as hardware reliability, but it is not directly related to time, depending upon the exclusive characteristic of Network. These exclusive characteristics are as follows:

- **Failure cause:** Network defects are mainly Design defects.
- **Wear – Out:** Network does not have energy related wear – out phase. Errors can occur without warning.
- **Time Dependency & Life Cycle:**
  Network Reliability is not a function of operational time.
- **Environmental Factors:** These do not affect Network Reliability, except it might affect program inputs.
- **Reliability Prediction:** Network Reliability depends upon human factors in design.
- **Redundancy:** It cannot improve Network reliability if redundant Network component are used.
- **Built with standard components:** Well-tested standard factors can improve reliability. But in Network industry it is not the established trend.
- **Behaviour of Network:** The life of the Network can be divided into three phases:
  - Test / Debugging
• Useful – Life
• Obsolescence
The behaviour of Network can be graphically displayed as follows:

Initially, when the Network is developed, during its test/ debugging phase, its failure rate is decreased to some value & then it is delivered to the customer. Now the product is operational in the customer site. Some failure may occur, in order to fix it, it may induce other defects into the Network. Therefore the failure rate may increases.

Even though customers may want to upgrade the Network with new features. For feature upgrades, the complexity of Network may be increased. As Network reliability is inversely proportional to complexity, it may be reduced. During its obsolescence phase, Network cannot be upgraded according to customer needs.

Based on the characteristics & behaviour of the Network, the reliability evaluation & improvement techniques has to consider new issues introduced such as redundancy of components is not going to improve the reliability of Network.

For evaluating the reliability; reliability models has to make assumptions & follows certain constraints such as according to Musa’s Execution time model the Network system is operating in an environment within an unchanging operational – Profile [5].

Based on the built with standard component characteristic of Network development, this trend was not that much popular. But now a day, component based Network development is very hot field among researchers in order to evaluate the reliability of Network system based on its components, as hardware system reliability. [6] In the hardware field, generally Markov based models are used to calculate the system reliability from component reliabilities. These models assume component independencies. But in Network field, Network components tend to violate the component independence assumption of the Markov based models. There are three problems faced by researchers as follows:

The first problem is that in a Markov model, a component invokes another component. But the Network module “uses” another module.

The second problem is that in a Markov mode, components are independent. But the Network modules may not follow this assumption.

The third problem is that standard components have to be deployed in different different environments. As the environment is changing, the operational profile may be changing. Estimating the reliability of standard components is difficult, due to changing nature of operational profiles.

According to J. Stafford & J. D. McGregor, [7] in their effort for creating a reliability prediction enabled component technology, they recognized the need to develop combinational reliability models to evaluate the reliability of components in component Based Network Development. These combinational reliability models are based on the assumption that the following items should have been considered:

- **Failure:** As CBSE supports the third party components to be used for Network development & there are many ways in which a Network product can fail & many ways in which a component can contribute to a given type of failure. Therefore the third party should have the knowledge of types of failures that are of interest to component users.

- **Network - Aging:** Although Network itself does not wear – out, there are environmental Conditions that can change over time & affect the ability of a component to do its job. The term Network aging is used to describe the effect of such type of Network faults. The effect of Network – aging on the reliability of Network products by using CBSE is an Open – Research Problem.

**A Common Interval Of Time Or Other Natural – Units:**
Component can be used in various Network products & a Network product can be used in many ways to provide different – different services to its users. The reliability of Network product depends upon the reliability of its constituent
components. When a Network product is executing, it is not necessary that each & every constituent components is executing. But the reliability of a component depends upon its use. The reported reliability will be with respect to some specific interval of time or natural unit but this may not have correct relationship in which it is going to be displayed. This reliability estimate must be modified according to which context it is going to be deployed.

**An Operational – Profile:**

As Network components are developed by third party. Determining an operational profile is very difficult because it requires the knowledge of the context in which it is used. Hence the operational profile validity is also very crucial to compute reliability of a Network system through CBSE.

**Communicating Reliability Information:**

As the reliability evaluation of a Network system depends upon reliability of its constituent components under CBSE. The reliabilities of components depends upon the operational profile. Therefore it is necessary to communicate the reliability information related to components with respect to operational profiles.

Based on the reliability estimation & prediction models we have developed some tools to support the reliability evaluation. But these tools have the limitation. These can be applied at the specific phase of the Network development life cycle. In order to build reliable Network systems, there is an increasing need to Assess the reliability of a Network product throughout its life cycle. But there is no specific tool, which will support this requirement. K.S. Trivedi et al. [8]

Provided an architecture of a Network reliability estimation & prediction tool which provides the unified framework which can be applied from the architectural phase of the Network to operational phase.

As already discussed that Network reliability cannot be evaluated directly. There is no clear definition, what aspects are related to reliability & up to what extent.

**IX. Conclusion**

Based on the above discussion the open research problem is to quantitatively measure the Network reliability enough to satisfy the user needs while maintaining the balance between cost & development time. This research paper is helpful for the researchers who are willing to pursue their research work in the Network reliability field.

**References:**


