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# *A REVIEW OF COMPUTER NETWORK RELIABILITY ANALYSIS*

Godwill Udoh, Dr Caroline alenoghena, Dr Bala Salihu
Telecommunication Engineering Department
FUT, MINNA
Minna, Nigeria
godwilludoh@gmail.com, carol@futminna.edu.ng, salbala2000@hotmail.com

*Abstract*— **Network reliability, as a field, is focused on questions of topological disconnection between data nodes. Most computer network reliability problem is primarily resolved by calculating efficiently the probability that some specified set of nodes in understudied network can communicate with each other at a given time. Network reliability analysis cuts across the design, deployment and testing of computer networks. Review reveal two major approaches to reliability analysis of computer network these are Path/cut enumeration and Case analysis which utilizes the concept of graph decomposition. The measures of computer network reliability analysis include issues on connectivity, capacity and travel time. The different parameters used in defining the reliability of computer-communication system include; Failure Rate, Mean Time To Repair, Mean Time Between Failures, Mean Time To Failure and Availability**

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***Keywords- reliability analysis,computer network,reliability index,network reliability***

## I. INTRODUCTION

All Effective communications is critical in determining the economic, social, innovative and military prowess of modern day society; this is hinged on the fact that effective communications is a keystone in all human activities. This communication is majorly effected by data nodes. A data node could be a mobile phone, information centers, encrypting and decrypting machines etc. which have evolved into what we call computers in today's world. Thus, the design and deployment of reliable data nodes has been given a high priority and this has enhanced the study of Computer Network reliability analysis as a field on its own. Network reliability is concerned with the topological disconnection between data nodes. Most computer network reliability problem is primarily resolved by calculating efficiently the probability that some specified set of nodes in understudied network can communicate with each other at a given time. Network reliability analysis cuts across the design, deployment and testing of computer networks.

As communication is now centered on computer networks, the design of reliable computer networks is much needed. Reliability analysis of a computer-communication network gives "worthiness test" of the infrastructure or relevant components that constitute the computer network and as such, seeks to evaluate the relevance of the computer network to its intended design expectations.

There have been efforts by researchers using various approaches in determining the reliability of a computer network and as such a review to classify the approaches and define most suitable method of analyzing understudied Computer network is needed. In this paper a review of computer network reliability analysis is carried out and presented in five subheadings. Section 2 gives the different approaches to reliability analysis of computer networks, section 3 describes the measures of reliability analysis, section 4 gives a description of different parameters that can affect network reliability and conclusion is presented in section 5.

## II DIFFERENT APPROACHES TO RELIABILITY ANALYSIS OF COMPUTER NETWORKS

Wherever Network Reliability defines the probability that an understudied Network can perform its stated function to an acceptable level of performance for some given period of time [1]. Any specific measure of reliability, thus, depends on the nature of the desired function and what levels of performance are acceptable. Earliest works on Network reliability was around 1950, with connectivity of networks been used as the reliability index [2].

Different set of algorithms are employed in reliability analysis of computer networks. The algorithms used can be grouped into two;

A. Path/Cut Enumeration:

This entails the listing of all the simple paths between the terminal nodes, which represents a complete set of favorable (unfavorable) non-disjoint events. Simple paths are links in the network that connect set of nodes while prime cut sets are links in the network which when disconnected cause the network to fail. The simple paths are considered as sets of favorable events while the prime cuts as set of unfavorable events. Reliability analysis entails summing the terminal reliabilities of these paths which is an indication that each

node communicates with a designated node. To obtain the computer network reliability, the inclusion-exclusion techniques of path and cuts is carried out. More efficient techniques based on Boolean algebra, can be utilized [2] – [7]

B. Case analysis:

Case analysis uses the method of graph decomposition. This entails the creation of subsets from the pathsets, either around a single keystone edge or around a number of edges/links/paths. A keystone edge is simply the node from which the factoring is referenced. When more than one edge is considered, graph decomposition is restricted to a conservative policy as against an exhaustive one. Using a conservative policy minimizes the number of disjoint events in the analysis. Disjoint events are simple paths that are not connected or have common node. This decomposition simplifies the analysis and helps cancel out occurrence of parallel links

## III. MEASURES OF COMPUTER NETWORK RELIABILITY

A good index for measuring the utilization of a computer network reflects that a network fails, often times, gradually, that some nodes and/or links are more important than others, and stated index is not based on traffic patterns. Possible measures with the above requirements include; terminal, "capacity-related", and "travel-time related" reliability measures.

### *A. Terminal Reliability*

Terminal Reliability is the probability that there exists an end-to-end connection between two or more nodes in a computer network needed to keep the network up and running [9]. There are basically 3 variants; K-Terminal, 2-Terminal and All-Terminal Reliabilities.

K-Terminal Reliability: The predominant measures of reliability when applied to computer networks are mainly specialized cases of k-terminal reliability. This is defined as the probability that a path exists and connects k terminals (nodes) within the network [10] [11]. This reliability is the sum of the probabilities of disjoint success paths [12].

Two Terminal Reliability*:* This is the probability that a communication exists between a specified pair of nodes in the network [13] [14].

*All Terminal Reliability:* This is the probability that every node in the network is able to communicate with each other [15] [16]. Two terminal and all- terminal reliability are modifications on the K- Terminal measure where K = 2 and K = n (n is the number of nodes in the network), respectively.

### *B. Capacity-Related Network Reliability*

This field is an extension or specialization of the research in computer network reliability. It is acknowledge that not all links (edges) may have the same capacity (weight, bandwidth).Further, it is also considered that the capacity demanded of the network is variable. Capacity-Related computer network reliability defines the network reliability in terms of the bandwidth (variable or fixed) needed to establish efficient data-throughput between nodes [17] [18]. It places a benchmark requirement (bandwidth) needed for connectivity between nodes having fixed or variable link capacities. It is used when the data requirement is same or more than the channel bandwidth and/or subscribed bandwidth.

### *C. Travel Time Network Reliability*

This basically defines the time taken for data to travel between link ends or nodes. It also describes the time taken for a hand shake to occur between specific nodes in a network and uses this as an index to measure reliability.

## IV. COMPUTER NETWORK RELIBILITY PERFORMANCE

Network reliability cannot be fully defined without taking into consideration some parameters that affect computer network performance. Different parameters that affect network reliability of a computer-communication system are described below [19]. They include failure rate, Mean time to repair, mean time between failures, mean time to failure and availability,

A. Failure Rate (FR) is the number of failures experienced or expected for a device divided by the total equipment operating time.

B. Mean Time to Repair (MTTR) is the amount of time spent performing all corrective maintenance repairs divided by the total number of these repairs.

C. Mean Time between Failures (MTBF) is the mean time expected between failures, measured in hours. For constant failure rate systems, MTBF is the inverse of the Failure Rate.

Equation 1 gives the mathematical formula for evaluating MTBF

$$MTBF = 1/FR \quad (1)$$

D. Mean Time to Failure (MTTF) is the mean time expected before the first failure of a piece of equipment. It is meant to be the mean over a long period of time and a large number of units.

E. Availability (A) is the probability that a system is operational when called upon to perform its function. Availability and unavailability (1-A) are often expressed as probabilities.

Equation 2 gives the mathematical formula for determining the availability of the network.

$$A = MTBF/(MTBF + MTTR) \quad (2)$$

## V. EVALUATION OF COMPUTER NETWORK RELIABILITY INDEX

Reliability analysis of a computer network invariably leads to evaluating a reliability index for the network. This is implied since reliability, like availability, is expressed as probabilities. A reliability index defines a scale on which the reliability of a computer network; that is, the probability of failure-free operations of the network over a period of time, can be measured. This scale ranges from 0 – 1. A value of zero implies a failed network while one means an "excellent" reliable network. The computer network reliability performance parameters described above are used in the evaluation of Reliability (R) index of the network. Computationally we have;

$$MTBF = \int_0^{\infty} R(T)dT \quad (3)$$

$$R(T) = e^{-(\frac{T}{MTBF})} \quad (4)$$

*where T is the number of hours*

$$MTBF = 1/(FR1 + FR2 + FR3 + - - -FRn) \quad (5)$$

Where 'n' is the number of components in the system

Therefore,

$$R(T) = \sum_{i=1}^{n} Ri(T) \quad (6)$$

The reliability of a computer network is invariably a sum of the probabilities of the individual components of the communications aspect of the Computer communication network understudied.

## VI CONCLUSION

The objective of a typical computer network reliability analysis is to obtain an index against which the reliability of the understudied network can be measured. Though a review of computer network reliability has been carried out in this paper, further work is been done on implementing the above stated discourse on an existing computer network. The intent of this is to observe and document (if any) variations from the review, give recommendations for future expansion and deployment of network facilities and determine the reliability of the understudied network.

Reliability analysis can be carried out for a proposed network and an existing network. This is to ensure better choices of network components, network topology deployment and flexibility in expansion and upgrading of network. The Reliability analysis of Computer Networks forms a veritable tool in defining the worth of a network to its intended design expectations and as such seeks to give a measure for user satisfaction. It invariably forms an important criteria to enhancing Quality of Service – QoS

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