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COMPUTATION OF COMMUNICATION NETWORK's RELIABILITY BASED ON SERVICE INTERRUPT

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Abstract

In distributed communication network a successful communication is a primary consideration. Many approaches have been taken to measure the probability of providing a success service for end users. However, almost all of these approaches are suitable for only one single node and are not computationally feasible for large networks. Other network's elements such as server's software which could be an essential element in a series elements configuration are omitted. In this paper the overall Reliability of a network are computed based on failure probability experienced from the network's reported outages. Reliability computation is independent on time; instead it reflects the number of outages and their impact on providing the network success. Availability takes into account the duration of the failure rather than the number of failures encountered.

1. INTRODUCTION

We are likely to meet a future where we rely on an increasingly wider range of information and communication services in our private, social and professional life. In addition to what we are familiar with today, some services will be invisible and provided by an ambient intelligent network. A part of the services will not be critical, while a continuous functioning of others will be mandatory for our productivity and well-being. All of these services are intended to be provided by one integrated communication infrastructure. This requires that attention should be paid to Reliability, availability, and continuity of the service. The two main issues of dependability are the Reliability and Availability, i.e. dependability issues.

This ensures the necessity to have a well constructed model for the network to trace its behavior in order to notice any deviation of its intended Reliability and Availability. The paper concentrates on the system and service levels of the network, particularly, how to convert the failure field data to a form that is easily use this data in a model set to compute the network performance dependability.

2. DEPENDABILITY

Dependability of a network is the ability of the network to deliver service that can justifiably be trusted. dependability is defined as trustworthiness of the system, A systematic exposition of the concept of dependability consists of three parts: the attributes, the threats, and the means by which dependability is attained.

2.1 Failures

Correct service is delivered when the service implements the system function. A system failure is an event that occurs when the delivered service deviates from correct service. A system may fail either because it does not comply with the specification, or because the specification did not adequately describe its function. A failure is a transition from correct service to incorrect service. A transition from incorrect service to correct service is service restoration. The time interval during which incorrect service is delivered is a service outage. Failure rate is the number of failures per unit time, and is expressed with the constant lambda (λ) with the unit of failures per hour (FPH), usually expressed in failure per million hours (FPMH) [1].

In calculating dependability attributes, failure rate must be calculated first. Failure rate can be divided into three levels, component failure rate level, device failure rate level, and system failure rate level. The most important fact is that component failure rate leads to device failure rate, since a device composed of may be tens or hundreds of components. Similarly, device failure rate leads to system failure rate [2].

2.1.1 Quantifying failure

The failure may be critical in that there is a total loss of the function of the system and it can no longer be used or just that the item has gone out of its specification limits but can still be used.

For an item which is tested for a time t and repaired each time it fails, then if it fails N times, the mean time between failures (MTBF) is:

$$MTBF = t/N \quad \ldots\ldots (1)$$

If over a time t there are N failures, then:

$$\text{Failure rate } \lambda = N/t = 1/MTBF \quad \ldots\ldots (2)$$

2.2 Reliability

Is one of the main aspects of dependability referring to the continuity of a system correct service without failure for an intended period of time. It is the probability that an item will perform a required function, under stated conditions, for a stated period of time. Since quality is defined as conformance to specification, reliability is therefore the extension of quality into the time domain. Usually the exponential law is used to compute the Reliability [3].

$$R = e^{\lambda t} \quad \ldots\ldots. (3)$$

Reliability Block Diagram could be set to explain the configuration of the network which implies the relation between the main parts of the network. Two main configurations are used, the AND configuration for series connection of the network's parts, or the OR configuration for parallel configuration [4].

2.2.1 Reliability Block Diagram (RBD)

Reliability computation of any network based on its failures requires the setting of its configuration so as to describe the relations between various parts that form the way of providing the service. Namely the two configurations necessary to compute the Reliability are the OR and the AND configurations. For a network divided into two parallel parts in series with other two series parts, the RBD will be drawn as shown in figure (1). Blocks C1 and C2 are in series hence taken as AND configuration. Blocks C3 and C4 are in parallel so taken as OR configuration. Systems composed of only series components are known as sequential system. On the other hand systems composed on parallel components are said to be redundant or concurrent systems. Other systems may compose of sequential and redundant items in which case are called hybrid configuration or AND-OR systems [5].

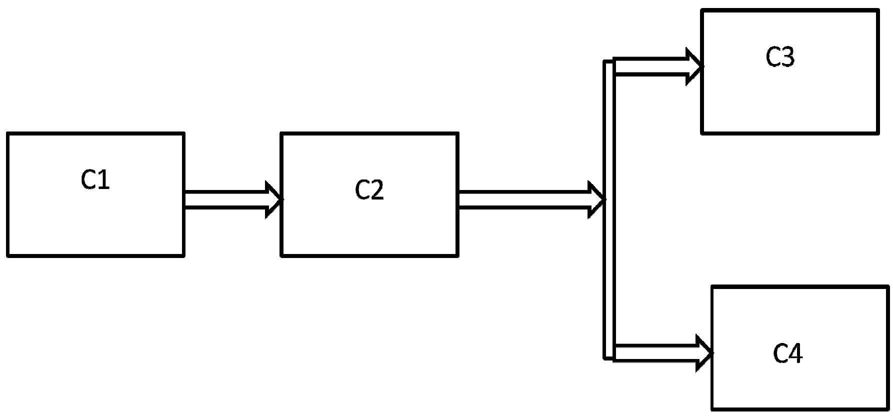

Figure (1) Series-Parallel Configuration

3. NETWORK's RBD

For all networks, the sequential or series configuration is the basic configuration since it describes the passage of required service from an item to another till it reaches the output to the end user of the system. In sequential system, all items of the system must function successfully for system success. It called AND configuration because the failure of any of the items in series will cause system failure [6].

The two basic components of any network are considered to be the Server, and the Channel.

Network service providing or system success depends essentially on these two items success which explicitly means should be running without failures as illustrated in figure (2).

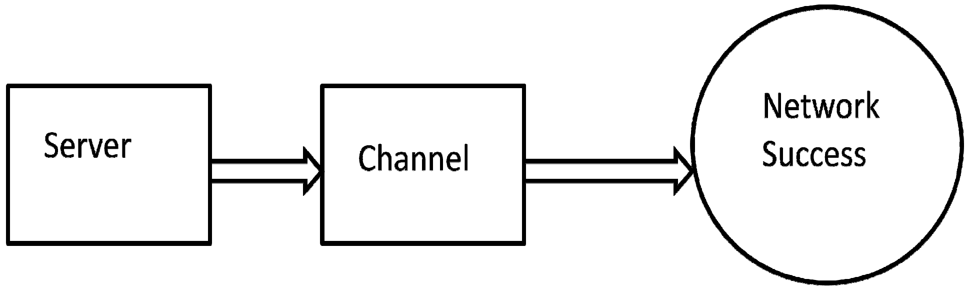

Figure (2) Network success

3.1 Network's Reliability measurement

The two main items of any network namely the server and the channel are sequentially arranged for system success, or network service delivery. For any sequential configuration system all items must function successfully for the system success, the failure of any of the item will cause the system failure. Thus the overall system reliability, R_s is given by [7]

$$R_s = \prod_{i=1}^{k} R_i = R_1 R_2 R_3 \ldots\ldots R_k \qquad \ldots\ldots(4)$$

Where R_i = item reliability.

The unreliability UR represents the probability of failure F(t) computed as

F(t) = 1 – R(t) …… (5)

This can be rewritten as:

R(t) = 1 – F(t) …… (6)

3.2 Desired Reliability and Failure Rate Computation

Assuming that failure rate λ of the channel is 5.7E-4 F/H (Failure per Hour), one can compute the required Reliability of the server to have for example 80% of the overall network's Reliability R_n for a year (8760 hours) and hence what is maximum failure should be maintained to obtain this level of the network's Reliability. This is computed as follows:

λ of the channel = 2.7E-5 F/H , thus R_{ch} of the channel could be found from (3) as:

$R_{ch} = e^{-\lambda t} = e^{(-1.7E-5)8760} = 0.86 = 86\%$ hence

$R_n = R_{ch}.R_{sv}$ where R_{sv} is the server Reliability

$0.8 = (0.86).\ R_{sv}$ then

$R_{sv} = 0.8/.86 = 0.93 = 93\%.$

$\lambda_{sv} = (-1/t).\ln.R_{sv}$

$= (-1/8760) \ln (0.93) = 8.3E-6$ F/H

This is the failure rate of the server that must be kept to obtain the desired overall network Reliability equal to 80% for a year.

3.3 Reliability of Redundant Server Network

Since a redundant channel network is impractical and costly, for a redundant server system, the failure of both servers is required for system failure, and this will increase the overall Reliability of the network due to the following computation:

The overall probability for concurrent system F_s is equal to:

$F_s = F_1.F_2.F_3..........F_k.$ ...... (7)

Where F_k is the last item failure probability.

Since $R_s = 1 - F_s = 1 - (F_1.F_2.F_3.......F_k$

Substituting for F = 1 – R gives

$R_s = 1 - [(1 - R_1).\ (1 - R_2).\ (1 - R_3)......... (R_k)]$

$$R_s = 1 - \prod_{i=1}^{k}(1 - R_i) \qquad ...... (8)$$

For two concurrent items system, the overall reliability R_s can be calculated as:

$R_s = 1- (1 - R_1).(1 - R_2)$ ......(9)

$= 1 - (1 - R_2 - R_1 + R_1R_2)$

$= 1 - 1 + R_2 + R_1 - R_1R_2$

$= R_1 + R_2 - R_1R_2$ ...... (10)

Assuming that the two servers are equal in hardware and software structure, and each has 0.82 Reliability, the overall Reliability will be found as:

$R_n = R_1 + R_2 - R_1R_2 = 0.82 + 0.82 - (0.82)(0.82) = 0.9676 \approx 0.97 = 97\%.$

4. RESULTS

The most important consideration in providing a continuous service of the network is to decrease the failure rate (λ). Reliability (R) of less than 0.95 may be disturbing and not suitable for critical services. Engineers and network administrators should do well to maintain an acceptable level of Reliability.

Table (1) describes different levels of failure rates and Reliability to assist in choosing out the appropriate level according to the service delivered.

Table (1) Different levels of λ and R

λ (F/H)	R %
8.3E-6	93
5.E-6	95.7
4.E-6	96.6
4.E-7	99.6
Zero	100

The table shows that to have a high level of Reliability two nines percent for example, the failure rate should be kept as low as possible.

The especial case of zero failure rate yields 100% Reliability which is considered as an unreachable value since the absence of failure could not be accomplished practically.

Reducing the network's failure rate is the responsibility of the network administrators with cooperation of the maintenance engineers.

A Reliability team must be an essential part of any network to improve the Reliability.

5 CONCLUSION

As networking becomes a part of our lives, we are becoming dependent on them. We rely on them, and thus we need them to be highly reliable.

Reliability is an important requirement for networks. This paper introduces and investigates the topic of Reliability modeling for networks. The results of Reliability modeling and analysis, if properly considered, will directly influence the network performance, and strongly guide the future design decisions. This fact requires that Reliability modeling and analysis should form an integral part of the network design, operation, and development stages.

The paper has mathematically modeled the Reliability as an exponential growth depends mainly on the value of the failure rate throughout a year or 8760 hours.

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