FAILURE EVENTS TREND ANALYSIS OF COMPUTER SYSTEMS IN NIGERIA

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ABSTRACT

This paper discusses the failure events trend analysis of computer systems and peripherals in developing countries taking the Nigerian experience as a case study. We identified and considered the manner and effects of failure events using empirical method to evaluate the quantities mean time to repair and mean time to detect (MTTR and MTTD). The data obtained were analysed using the method of weighted average which was employed to compute failure events probabilities.

The results of this research shows that computer systems and peripherals in developing countries, especially, in Nigeria failed largely as a result of a significantly noticeable reduction in quality control substances included in the design recently manufactured and imported computer systems and peripherals.

Keywords: Failure Events, Viability, Weighted Average, MTTR, MTBF, MTTD, Median Value Policy Issues.

1.0 BACKGROUND OF THE STUDY

Nigeria ostensibly since the early 1980s has accepted information technology (IT) as a veritable resource in the country's quest for development technologically, economically, and socially. One major component of IT is the computer system and peripherals.

It is obvious that every computer system and peripheral will eventually fail. It was observed that there is an inverse relationship between the quality of service obtainable from IT equipment, in terms of viability, and the number of computer literates in Nigeria over a ten year period (1990 - 2000). Computer revolution, a phenomenon noticed three decades ago in the advanced nations of the world, has just begun in Nigeria. At the dawn of computerisation, in the West, mainframe and minicomputer systems were in vogue. Therefore, because of the sheer sizes of these computer systems then, their use was restricted to large organistions and corporations as against microcomputers that more are favoured for the same purpose, and even as personal computer systems presently. So also, an increasingly huge volume of microcomputers has been deployed for use within the country in recent years. The distribution of end-users cuts across private establishments, government agencies, educational institutions, recreational centers and the home. The pervasive use of the computer systems in the country has led to a number of issues, one of which motivated the authors of paper into this research work. Worthy to be mentioned among the issues are: indiscriminate importation of computer system components and peripherals into the country, after-sales support service availability, equipment quality assurance and maintainability, to mention a few. Equipment maintainability is the central point in this paper.

1.1 Problem definition

According to [1], maintainability is a statistical expression of the quantity mean time to repair (MTTR) that is required in viability analysis. Viability is a concept used in the architecture and engineering of digital computer complexes which evaluates the compound probabilistic measure of a system's capability. The other components of viability include - performance and reliability. In practice and in theory, a system that cannot fail is unachievable. So therefore, It is obvious that every computer system and peripheral can and will eventually fail. Hence, it remains to consider the manner and effect of those failures and the cost of minimising them. In this paper, we identified the various manners failures in computer systems and peripheral were demonstrated over a ten years period (1990-2000), causes of failures over a ten years period and the effect t of those failures on MTTR.

The justification for this study will be its application as an information system base to:

- Government regulatory bodies responsible for policy formulation and monitoring as it affects imported good standardisation such as Standard Organisation of Nigeria (SON), Customs and Excise department etc.
- Governmental agencies responsible technology acquisition and promotion such as National Office Technology Acquisition a nd P romotion (NOTAP), Federal Ministry of Science and Technology etc.
- Federal Office of Statistics and Federal Ministry of Trade and Industries.
- Universities and research institutions.
- Prospective foreign investors and partners.

2.0 METHODOLOGY

2.1 Location of study

The methodology of study is mainly empirical. Data used in analysis were gathered from the equipment maintenance center of the department of computer science and engineering, Obafemi Awolowo University (OAU), Ile-Ife. In addition to the empirical data, interviews were also organised with selected computer system and peripheral servicemen in Lagos and within Ile-Ife. According to Information Technology and Communication Unit (INTECU), there are a bout 1000 computer systems on the OAUnetwork (OAUNET). Apart from computer systems used within the university, independent users from within the environ of Ile-Ife town bring in faulty equipment for repairs and service.

2.2 Sample used in the study

Samples were drawn from various users ranging from individuals (staff and students), coporates (faculties, departments and units), small and medium scale-businesses. We also noted, from interviews conducted with users as preliminary step to troubleshooting procedure, that large number of users deployed computer system largely for wordprocessing and very minimal number for data analysis and database management activities. The frequency of users at the center is modeled as a discrete random variable and memoryless too [4]. There are situations in which a user came in with two or three devices that demanded entirely different expertise from the servicemen.

2.2.1 Types of samples

The types of samples belong to the hardware sub-system of the computer system only. From our records, we found out that within the system unit, the power supply unit constituted more ninety percent (90%) of system unit fault. These power supply units were predominately AT-standard designed for Intel Pentium II Processor Mainboard and earlier versions. But, recently ATX -standard power supply units designed for Intel Pentium III and later version gradually taking over. Secondly are the video display units otherwise referred to as monitors. These devices are described as 14-inches Video Graphic Array (VGA) with high colour resolutions (1024 X 768). On the aggregate, monitors contributed more than two-thirds of daily job entries at centers. Printers and Uninterrupted Power Supply (UPS) contributed least to the number of jobs at the center. We have observed an average of one printer per week. There are two major types of printers usually brought down for repairs and maintenance - the Injets and the LaserJet. The Laserjet printers are less frequent than the Injet printers. Laserjets are more tolerable to usage than Inkjet printer most often; they required only service and less electronic circuit troubleshooting. UPS are rarely noticed, the frequency is about one UPS per fifteen week (Semester). A faulty UPS requires a high-level manpower skill to diagnose its electronic circuitry and to effectively repair it. However, UPS battery is the problem area, especially when they have been run down excessively by poorly informed users.

2.3 Tools and troubleshooting method

In the process of troubleshooting faulty equipment, a viva session is always arranged between the users and a serviceman. The imports of a viva session are:

- to establish the use to which the equipment is being put,
- to picture the working conditions the equipment must have been subjected to and
- how and when the fault was noticed on the equipment.

Also, the main tool used for diagnosis is the Multimeter (digital and analogue). The multimeter is used to test electrical components, both passive and active, for short, open-circuited situations, and leaky junctions. Semi-conductor components catalogue is also used to check out the characteristics of active components as well as the Internet. Internet provides a most veritable information infrastructure on recent characteristics missing out` from catalogue.

2.4 Mathematical modeling

In section one, the quantity MTTR was introduced briefly. In another perspective, MTTR can be viewed as the measure of the expected time required to remove those events that have been accepted to constitute a failure in a device. On the other hand, MTTR may not be easily evaluated as the quantity Mean Time Between Failure (MTBF) which measures the expected time between conjunction of events that are accepted to constitute the failures [1]. Statistically, we have described MTTR empirical outcomes with a deterministic model [4]. However, the time required to repair a malfunctioning device consists of the time to follow a sequence of many steps to a logical conclusion whose duration is uncertain. Therefore there are steps required to accomplish a compound measure of MTTR:

- detecting that the failure has occurred
- isolating the malfunctioning element
- removing the malfunctioning element
- obtaining a replacement by either repair or from a stock of spare elements
- inserting the working element
- verifying that the replacement works
- initialising it
- initialising the system and
- resuming processing.

There is an imaginary stopwatch required to measure MTTR. The stopwatch is started only at the point of failure detection. But, the quantity Mean Time To Detect (MTTD) should be determined first before determining the result of MTTR. We can sufficiently model the number of trials until a successful repair as a geometric random variable given the probability of a successful repair.[4]

Moreso, the probability that a device is up is called the availability of the device. The availability of a device is given by

$$\text{Prob(up)} = \text{MTBF}/(\text{MTBF} + \text{MTTR}) \qquad (1)$$

While the probability that the device is down is given by

$$\text{Prob (down)} = 1 - \text{Prob(up)} = \text{MTTR}/(\text{MTBF} + \text{MTTR}) \qquad (2)$$

MTBF and MTTR should reflect the preventive maintenance policy put in place for the system. This is recommended because a device is down during maintenance periods as well.

Furthermore, in a system consisting of x subsystem, each subsystem can be either Up or DOWN. Therefore, there are 2^x possible conditions for the system as a whole. Associated with each state are a number of performance parameter values that characterised the capabilities of the system in that state. Therefore for a given system, the probability is expressed as follows for a given subsystem x:

$Prob_x(UP) \Rightarrow$ Probability that the subsystem is up

$$= MTBF_x / (MTBF_x + MTTR_x) \quad (3)$$

Conversely,

$Prob_x(DOWN) \Rightarrow$ Probability that the subsystem is down $= MTTR_x / (MTBF_x + MTTR_x) \quad (4)$

The probability of a given state is the product of the subsystem probabilities for that state. For example, given a computer system consisting of processor mainboard, power supply unit, visual display unit (VDU), a printer and an uninterrupted power supply (UPS) in which the power supply unit is faulty, its state probability is given below:

$Prob_{PSU}(DOWN) \Rightarrow$ Probability that the PSU is down

$Prob_{PSU}(DOWN) = Prob_{PSU}(DOWN) \times Prob_{processor}(UP) \times Prob_{VDU}(UP) \times Prob_{UPS}(UP) \quad (5)$

Thus, a general formula will be

$$= \prod_{i=1} \{MTTRx / (MTBFx + MTTRx)\} \quad (6)$$

Where

MTXy= MTBFy. If subsystem y is UP in state S

MTXy=MTTRy.If subsystem is DOWN in state S

To achieve a good maintainability, a low MTTR value is desirable.

3.0 OBSERVATIONS

The period under review is segmented into two halves. The first five and the last five years of the last decade, that is from 1990 to 2000. In the course of this investigation, we observed causes of faults. These faults range from mechanical to elecfrical in nature.

3.1 Mechanical-oriented Faults

Mechanical faults are common among peripherals associated with the production of output. An example of such output device is the printer. The common source of mechanical-oriented faults is often the users - negligence. The MTTD and MTTR values recorded in this case are very small when compared with electrical-oriented faults. The common faults noticeable are :-

- output medium jam as a result of faulty form-feed procedure or the use of sub-standard medium
- friction between two moving parts as a result of poor maintenance culture –lubrication
- use of tampered ink cartridges or sub-standard toner

3.2 Electrical-oriented Faults

These faults are noticeable in the peripherals that we came across. These faults are more difficult to diagnose and repair, so therefore contributing to large values of the MTTD and MTTR. The followings are the fundamental causes of electrical faults in computer system and peripherals from the user's perspective:

1. Over-usage (OU): this is a situation whereby the user was found to have subjected the equipment to a continuous working condition beyond the limit of the equipment under an unfavourable condition – high temperature [2]

2. Under-usage (UU): a situation found to be common with beginners. The equipment was perhaps used for awhile, thereafter packaged and kept in store for long period under unfavourable weather condition such as excessive humidity.[2]
3. Old-age (OA): a situation wherein the equipment fails to function as a result of aged electrical components such as electrolytic capacitors with leaky di-electric, leaky diode junction, weakened resistors and partial contacts.
4. Poor-power-supply (PPS): Power supply refers to the quality of electricity available to the users to power their computer system and peripherals. A poor state is synonymous to a situation of erratic and unstabilised electricity supply. The following conditions of electricity supply have been classified as poor:
   a. **Brown-out:** Brown-out is a condition of lower than normal power line voltage being supplied by local utility or generating equipment. This condition may be short term (minutes to hours) or long term (1/2 day or more). A power line voltage reduction of 8 - 12% is usually considered a Brown-out.
   b. Voltage upsurge beyond 20%.
   c. Power fluctuation
5. User-negligence (UN): user carelessness is another factor responsible for equipment failure. Newly acquired computer systems and peripherals have been reported faulty as a result of poor usage or handling. Most often we have found out the followings:
   a. Power supply mis-match (110/220volts).
   b. Exposure to unfavourable weather conditions such as excessive humidity, temperature, pressure and dust too.
   c. Over current drainage from auxiliary power sources – UPS batteries.
   d. Use of sub-standard output medium on printers such as LaserJet and inkjet printer.

3.3 Maintainability analysis

From empirical analysis carried out on equipment manufactured over the years (1990-2000), we have been able to estimate the average values of MTTD and MTTR for equipment repaired. First, equipment manufactured over (1990-1995) period has an estimated MTTR values ranging from 1hour to 2hours, while equipment manufactured from the year 1996 to 2000 have an estimated MTTR values ranging from 4hour to 6hours. We have assumed an MTBF value of 10,000 hours that is equivalent to one year of life span which usually specified for standard hardware by original equipment manufacturer [3]. Taking a median value of the MTTRs, we have

1. Median value $MTTR_{(1990\text{-}1995)}=((1+2)/2)=1.5$ hr
2. Median value $MTTR_{(1996\text{-}2000)}=((4+6)/2)=5$ hrs

From equation 2 above,

$Pr_{DOWN}\,(1990\text{-}1995) = 1.5 / (10{,}000 + 1.5)$

Approx value = 1/10000

While

Pr_{Down}(1996-2000) = 5/(10,000 + 5)

Approx. value = 5/10000

Thus, the probability that equipment manufactured in the first half of the last decade were available 500% more than those manufactured in the last half of the same decade.

3.3.1 Empirical results

We have adopted the method of weighted average in computing probability in this analysis. As stated in section two above, Arrival rate of equipment and the frequency of faults occurrences were obtained from the repair center log book. Therefore, we based the following analysis on the various equipment failures discussed in section three above.

From our empirical data distribution, we classified the faults into categories depending on frequency of faults occurrence and computed the weighted averages. The tables 1.0 and 2.0 show the classifications. Based on the tables 1.0 and 2.0, we present yet another set of tables (Tables 3.0 and 4.0) that shows the failure trends during then period under review.

3.4 Interpretation

Figures 1.0 and 2.0 below depict combined graphical representations of the failure trends for the two periods of the most commonly serviced parts in a computer system and peripheral. First, Figure 1.0 shows a comparison of the two periods under review for video display units (VDU). VDUs manufactured between the year 1990-1995 were found to suffer failure largely as a result of old age (OA), while those manufactured between 1996-2000 suffer failure largely as a result of poor power supply (PPS). So also, it is obvious from the same figure that VDUs of 1990-1995 demonstrated a high degree of reliability and availability towards failure events such as UU, OU, PPS and UC as against VDUs of 1996-2000. In the figure 2.0, the reports are also similar. Except that a corresponding probability in one is almost twice as high for the failure events such as OA, PPS and UC.

4.0 CONCLUSION

The interpretation of these observations demonstrates and established the motivation for this study. Our motivation being a significantly noticeable inverse relationship between the quality of service of information technology (IT) equipment, in terms of viability [1], and number of IT equipment users in the Nigeria economy over a ten year period (1990-2000). Furthermore, it is not an overstatement that the same period experienced a very high demand for IT equipment, while quality of service was being jeopardized for cheap cost and huge quantity by importers. From the users' perspective, users suffered huge capital losses as a results poor maintainability and availability of these computer systems and peripherals. Moreso, the economy of the small scale entrepreneurs revolves largely on the use of computer systems and peripherals for the running of the following enterprises:-

Internet kiosks, Business Centers and Printing Presses, which have suddenly *become* major positive contributors to the nation Gross Domestic Products (GDP). These enterprises have provided significant vocational job opportunities for: ***Semi-literates, Young school levers and, Undergraduate holiday makers***, and also Investment opportunities for ***government and private establishments' retirees***. So also, distance learning education, in particular, the National Open University's implementation which is at its infancy is designed to deploy immensely IT equipment and the Internet to supplement existing infrastructure for University education in the country may suffer, if this situation is not re-dress nationally. Lastly, from a technical point of view, we have found that there has been a reduction in quality control substances included in the designs of recently manufactured and imported computer systems and peripherals as shown in figure 1.0 which presents a much lower probability of **OA failure event** for **1996-2000** as against **OA failure event** for **1990-1995.** This translates to very low availability values for equipment manufactured and imported between1996-2000 as against those of 1990-1995. However, this assertion might exclude propriety or branded computer systems and peripherals. On the other hand, **PPS failure event** faired better for those of **1996-2000** as against **1990-1995** because power supplies have standardized the design principle of auto-switching as against manual switching from 110 VAC to 240 VAC in the earlier years. Moreso, modern power supply units exhibit greater tolerance to unstable electricity supply as against the older designs.

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Table 1.0: Video Display Unit Probability Table

	Arrival Rate (Units/4 weeks)	Categories	Points	Weighted Average
Video Display Units	0-1unit	Rarely probable	1	.06
	2-3 units	Slightly probable	2	.13
	4-6 units	Probable	3	.20
	7-9 units	Highly Probable	4	.266
	10 units and above	Mostly Probable	5	.33

Table 2.0: AT Power Supply Probability Table

	Arrival Rate (Units/4 weeks)	Categories	Points	Weighted Average
System Unit Power Supply	0-1unit	Slightly probable	1	.1
	2 units	Probable	2	.2
	3-4 units	Highly Probable	3	.3
	5 units and above	Mostly Probable	4	.4

Table 3.0: VDU FAILURE EVENTS PROBABILITY DISTRIBUTION

	UU	OU	OA	PPS	UC
1990-1995	R	R	M	S	P
1996-2000	R	S	R	M	H

Table 4.0: POWER SUPPLY UNIT FAILURE EVENTS PROBABILIY DISTRIBUTION

	UU	OU	OA	PPS	UC
1990-1995	S	S	P	S	P
1996-2000	S	S	M	H	M

FIGURE 1.0 :FAILURE EVENTS PROBABILITY DISTRIBUTION FOR VDU

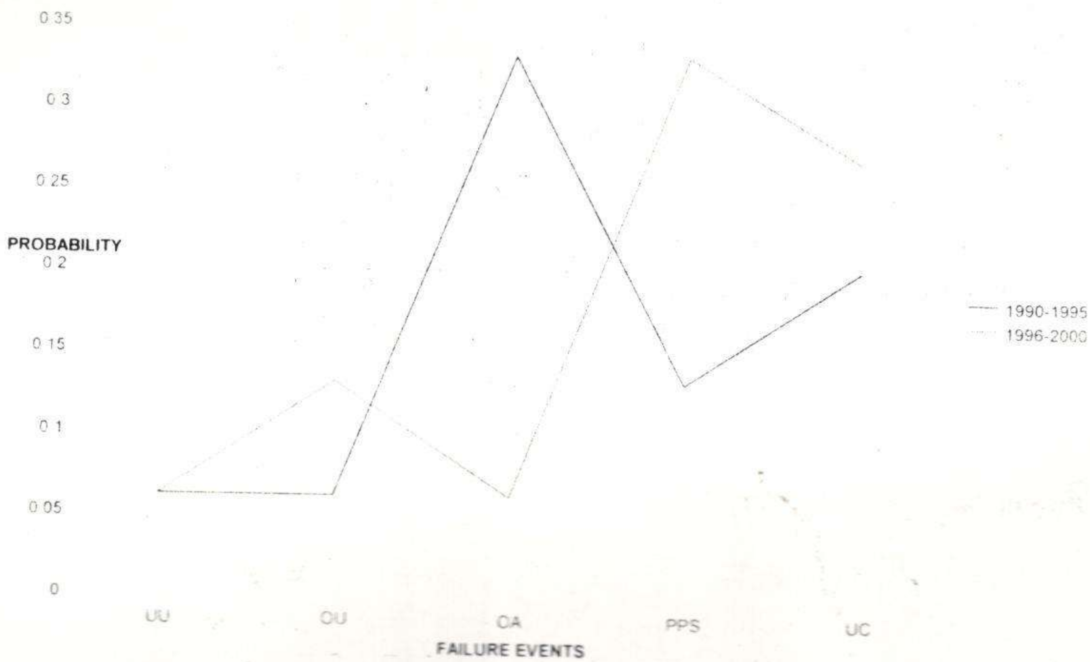

FIGURE 2.0:FAILURE EVENTS PROBABILITY DISTRIBUTION FOR POWER SUPPLY