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SEVERITY INDEX ANALYSIS OF THE PROBLEMS OF OPTICAL FIBER COMMUNICATION IN NIGERIA: A CASE STUDY OF SOUTH EASTERN NIGERIA

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ABSTRACT

Optical Fiber is a major building block in telecommunication infrastructure. Its high bandwidth capabilities and low attenuation characteristics make it ideal for high data rate transmission. Due to its advantages over electrical transmission, optical fiber has largely replaced copper wire communications in core networks in Nigeria and many developed nations. Despite the numerous advantages, they are faced with several drawbacks in Nigeria which include: difficulties in integrating it into existing communication systems, complex and expensive installation and operation, and poor implementation of underground cabling master plan. The objectives of this study are to identify and statistically appraise the problems of the optical fiber communications in south eastern Nigeria. The research was carried out in two phases. In the first phase, interviews with various telecommunication operators and Nigeria communication commission (NCC) personnel, and literature review were conducted. The first phase resulted in the identification of 17 problems which were subjectively grouped into four categories, namely: Governmental problems, man-made problem, planning and design problems and natural problems. In the second phase, Questionnaire was developed based on the identified problems and given to a randomly selected 23 NCC personnel and operators in the area of study. The relative severity effect of each problem was assessed and then ranked based on a severity index by both NCC personnel and operators. The NCC evaluated 3 problems as "most severe", 7 problems as "moderately severe", 7 problems as "slightly severe" and 0 as "non severe". While operators evaluated 4 problems as "most severe", 11 problems as "moderately severe", 2 problems as "slightly severe" and 0 as "non severe". Spearman's rank correlation coefficient formula was used to test the degree of agreement in the ranking between the NCC and Operators. It was found that the operators agree with the NCC on the ranking of the severity of the problems.

Key Words: *Optical* Fiber; Telecommunication Operators; NCC; Severity Index

INTRODUCTION

Optical fiber communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber (Kumar, 2005). It's principle of operation is based on the refraction of light, thus, it transmits data at the speed of light. Because of its advantages over electrical transmission, optical fibers have largely replaced copper wire communications in core networks in the developed world.

Despite the numerous advantages of Optical fibre communication systems, they are faced with several drawbacks. This includes difficulties when integrating fiber optics into existing communication systems, installation and operation is complex and expensive and also, time

and effort needed in implementing fiber optics in existing systems such as LANs require great deal of changes to current networks which most companies are not willing to do.

Past research have shown that the high cost of using fibre optics in communication can be offset by deploying them in long distance applications, where they can be used to their full transmission capacity. In Nigeria, the high demand for data services and general increase in telecommunication traffic means that short distance implementation of fibre optic communication becomes cost effective.

However, this work is focused mainly on the problems that affect fibre optic usage in Nigeria, since it is known from available data that it is the fastest and most effective communication medium available in the country.

The objectives of this study are to identify the problems of optical fibre communication in South-eastern Nigeria, the extent to which these problems have affected communication in the region and to recommend solutions (where possible) to the identified problems.

This study will be very helpful in proffering solutions to existing problems associated with;

a. Increased cost as a result of inadequate power supply.
b. Sabotage and vandalism.
c. Cost of deployment (labour and equipment).
d. Erosion and other natural problems.
e. Damage of optical fibre installations during road construction/ expansion.
f. Inadequate underground cabling infrastructure
g. Security of personnel and equipments.
h. Burning of refuse dumps over ducts.

The study was confined to the South-Eastern region of Nigeria. The questionnaires were retrieved from a total of forty-nine (49) respondents; twenty-three (23) from the Nigerian Communication Commission (NCC) and twenty-six from the telecommunication operators.

RESEARCH METHODOLOGY

The research, as earlier stated, was carried out in two phases. The first phase involved literature search and interview. From this phase, 17 problems were identified and grouped into four categories. These are: Governmental problems, Man-made problems, Planning and design problems and Natural problems.

In the second phase, using the various problems identified, a questionnaire was developed. The questionnaire was distributed among some randomly selected Nigerian Communications Commission (NCC) personnel and telecommunication operators in the area of study, which is the South-East of Nigeria. Lastly, the data collected from the questionnaire was then analyzed statistically using the severity index (Is) and the spearman's rank correlation coefficient (r) formulas.

PROBLEMS OF OPTICAL FIBER COMMUNICATION IN NIGERIA

Literature search Kumar (2005), Connect Africa (2007), Onwuegbuchi (2012), Business Day (2010) & Onwuegbuchi (2005) and interviews with operators in the area of study led to the discovery of 17 problems. These problems were classified into four categories with each category reflecting problems that have a common basis. The various categories and their associated problems are as follows:

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Governmental Problems

The under-listed problems are included in this category.

1. Road construction/expansion damage.
2. Irregular Power Supply.
3. Difficulty in acquisition of Right of Way.
4. Inadequate underground cabling infrastructure.

Man-Made Problems

The under-listed problems are included in this category.

1. Vandalism.
2. Sabotage.
3. Security.
4. Housing development on non-urban manholes
5. Burning of Refuse dumps over ducts.

Planning and Design-Related Problems

The under-listed problems are included in this category.

1. Degradation.
2. High cost of deployment.
3. Cable kink during aerial routing.
4. Inadequate optical power budgeting.
5. Cable damage as a result of fallen poles during aerial routing.

Natural Problems

The under-listed problems are included in this category.

1. Erosion damage.
2. Flooding.
3. Force Majeure (Unforeseen failures/threats).

Based on the identified problems, a survey of 26 telecommunication operators and 23 NCC personnel randomly selected from south eastern Nigeria was carried out to measure their evaluation of the relative severity of each defect. The respondents were given four (4) rating options: Strongly severe, moderately severe, slightly severe, and Non severe, and were expected to select any of these four options based on their judgment of the severity of the problem. The severity index (Is) of each of the problems was calculated as (Mendenhall et al., 2009)

$$\text{Severity Index} = \frac{\sum_{i=1}^{i=4}(aixi)}{3\sum_{i=1}^{i=4} xi} \text{ X } 100\% \quad \ldots .1$$

Where a_i = constant expressing the weight given to the i_{th} response, and a_i = 0, 1, 2, 3 for i = 1,2,3,4, respectively; a_1 = 0 is equivalent to "non severe"; a_2 = 1 is equivalent to "slightly severe"; a_3 = 2 is equivalent to "moderately severe", and a_4 = 3 is equivalent to "most severe"; X_i = variable expressing the percentage frequency for the degree of importance of each factor; X_1 = percentage of frequency of "non severe" responses; X_2 = percentage of frequency of "slightly severe" responses; and X_3 = percentage of frequency of "moderately severe" responses; and X_4 = percentage of frequency of "most severe" responses.

Table 1. Severity Indices and Ranking of the Problems by Both Respondents

S/N	*PROBLEMS*	*NCC PERSONNEL*		*OPERATORS*	
		INDEX (%)	*RANK R*	*INDEX (%)*	*RANK R*
A	*GOVERNMENTAL PROBLEMS*	*72.1*	*1*	*76.93*	*1*
1	Road Construction / Expansion damage	84.06	1	98.72	1
2	Irregular Power Supply	57.97	8	42.31	15
3	Difficulty in acquisition of Right Of Way	72.46	5	75.64	4
4	Inadequate underground cabling infrastructure	73.91	4	91.03	2
B	*MAN-MADE PROBLEMS*	*62.03*	*2*	*67.69*	*2*
1	Vandalism	72.46	5	83.33	3
2	Sabotage	49.28	10	61.54	9
3	Security	76.81	2	67.95	7
4	Housing development on non-urban manholes	43.48	12	53.85	12
5	Burning of refuse dumps over ducts	68.12	7	71.79	6
C	*PLANNING AND DESIGN RELATED PROBLEMS*	*49.85*	*3*	*55.90*	*4*
1	Degradation	40.58	13	44.87	14
2	High Cost Of Deployment	75.36	3	56.41	11
3	Cable kink during aerial routing	33.33	16	61.54	9
4	Inadequate Optical Power Budgeting	47.83	11	60.26	10
5	Cable damage as a result of fallen poles during aerial routing	52.17	9	56.41	11
D	*NATURAL PROBLEMS*	*47.34*	*4*	*62.39*	*3*
1	Erosion damage	69.57	6	73.08	5
2	Flooding	37.68	14	62.82	8
3	Force Majeure (Unforeseen failures/ threats)	34.78	15	51.28	13

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Table 2. Severity Indices and Ranking of the Four Problem Categories

		NCC PERSONNEL		*OPERATORS*	
CATEGORIES	*PROBLEM CATEGORY*	*INDEX (%)*	*RANK*	*INDEX (%)*	*RANK*
A	GOVERNMENTAL PROBLEMS	72.1	1	76.93	1
B	MAN-MADE PROBLEMS	62.03	2	67.69	2
C	PLANNING AND DESIGN RELATED PROBLEMS	49.85	3	55.90	4
D	NATURAL PROBLEMS	47.34	4	62.39	3

RESULTS AND DISCUSSION

The problems were then ranked based on their severity indices for both operators and NCC personnel. Table 1 shows the severity indices and ranking of the problems as evaluated by both respondents. Table 2 shows the severity indices and the ranking for the four categories. The severity indices were grouped to reflect the scale of the respondents' answers to the evaluation of the defects as follows:

"Most severe" problems $75 < Is \leq 100$
"Moderately severe" problems $50 < Is \leq 75$
"Slightly severe" problems $25 < Is \leq 50$
"Non severe" problems $0 < Is \leq 25$

The severity index of a category was determined by finding the average summation of the severity indices of its related problems (Table 2). Table 1 shows that the NCC personnel evaluated 3 problems as "most severe", 7 problems as "moderately severe", 7 problems as "slightly severe" and 0 problem as "non severe". Operators on the other hand, evaluated 4 problems as "most severe", 11 problems as "moderately severe", 2 problems as "slightly severe" and 0 problem as "non severe". Table 2 shows that the NCC personnel evaluated two categories as "moderately severe" and two categories as "slightly severe", while, the operators evaluated one category as "most severe", and the remaining three categories as "moderately severe". From the table, it is evident that both parties generally agree on the severity of two categories: governmental problems and man-made problems. However, both parties disagree on the severity of planning and design-related problems as well as natural problems.

DEGREE OF AGREEMENT IN THE RANKING

The Spearman's Rank correlation coefficient, *r* was used to measure the degree of agreement in the ranking of the NCC personnel and operators. The coefficient was computed using the formula (Iheagwam & Inyama 1995),

$$r = 1 - \frac{6\sum d_i^2}{n(n^2-1)}. \quad \ldots\ldots\ldots 2$$

Where d = difference between the NCC personnel ranking and the operators' ranking of each problem, and n = number of ranked variables. Using the data in table 1, the Spearman's rank correlation coefficient, r was found to be 0.6998.

Based on a null hypothesis that "the NCC personnel and the operators do not agree on ranking of the severity of the problems of optical fiber communication in Nigeria" set at 97.5% confidence level, a result was obtained which led to the rejection of the null hypothesis and acceptance of the alternative hypothesis that "the NCC personnel and the operators agree on ranking of the severity of the problems of optical fiber communication in Nigeria".

CONCLUSIONS

Based on the results of the analysis as seen in tables 1 and 2, the following conclusions were drawn: Road construction/expansion damage, inadequate underground cabling infrastructure, and high cost of deployment strongly affect optical fiber communication; Difficulty in acquisition of right of way, security, burning of refuse dumps over ducts, housing development on non-urban manholes, cable damage as a result of fallen poles during aerial routing, cable kink during aerial routing, inadequate optical power budgeting and erosion damage all have a moderate effect on optical fiber communication; while irregular power supply, sabotage, degradation, force majeure and flooding have a slight effect on optical fiber communication in south-eastern Nigeria.

RECOMMENDATIONS

To minimize the effects of these problems, the following recommendations were made:

Governmental Problems

a. Construction companies should be made to study the road plans to see where ducts are placed.

b. In situations where ducts cannot be placed 5meters away from drainages, they should be placed at the centre of roads where disturbances is minimal.

c. Operators should send staff to monitor road construction/expansion in areas where optical fiber cables are laid.

d. Better implementation of the duct master plan should be made by government.

e. Government should improve power supply in order to aid effective telecommunication in south-eastern Nigeria.

f. There should be a unified ducting system for fiber optical cables so that companies can lay new fiber cables without having to excavate the ground and damage existing fiber cables.

g. There should be a technical site survey, so that each new route is registered with the relevant Ministries and agencies.

h. During road construction, aerial routing can be used as a temporary measure to protect optical fiber installations.

Man-Made Problems

a. The security agencies must have full powers with relevant legislations made to combat vandalism. There should be appropriate penalties for vandals and saboteurs.

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b. Where possible, operators can set up monitoring teams made up of community youths to monitor their installations in rural areas.

c. Operators need to liaise with the host communities to agree on favourable operating terms to ensure safety of personnel and installations.

d. The relevant environmental protection agencies should ensure that refuse dump sites do not spring up in non-designated areas.

e. Operators should relocate their optical fiber installations where refuse dumps threaten their integrity.

f. In the case of housing development on non-urban man-holes, the operators need to reach an agreement with the land-owners in order to have unrestricted access to man-holes.

g. Non-urban man-holes should be upgraded to urban man-holes or route markers used in rural or sub-urban areas for easy identification.

Planning And Design Related Problems

a. Multiple splicing within a fixed distance should be avoided. A maximum of two (2) splices per kilometre is suitable. Splicing should be done with precision to limit splice losses to 0.03dB per splice.

b. Aerial routing should be used only temporarily or in situations where underground cabling is not possible.

c. Before aerial routing, the existing electric poles should be checked for structural defects.

d. Combating increased power losses by increasing transmitter power will have a negative effect on equipments and as such should be done only in extreme situations.

e. The problem of high cost of deployment can be minimized by leasing, or sharing of existing optical fiber routes.

Natural Problems

a. Galvanized iron pipes should be used in areas prone to flooding to shield the optical fiber cables.

b. Concrete cast should be used for man-holes in erosion prone areas.

c. In small cases of erosion, the solution is to backfill (cover) the affected areas with sandbags and stone-pitch. But in serious cases, relocation is a better option.

d. Armoured cladding should not be used for optical fiber cable as it is susceptible to lightning which could damage the fiber.

Rank Agreement

Using the 97.5% confidence level, it was shown that the NCC personnel and the operators generally agreed on the severity ranking of the identified problems.

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