Global Journal of Computer Science and Technology: C
Software & Data Engineering
Volume 14 Issue 2 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Effects of Mining Operations on Local Area Networks in Large Scale Gold Mining Environments in the Western Region of Ghana

By Emmanuel Effah & Christian Kwaku Amuzuvi

University of Mines and Technology, Ghana

Abstract- We investigate the impacts mining operations have on established Wired/Wireless Local Area Networks (WLANs) in mining environments in the Western Region of Ghana. Mining activities have certain immutable negative impacts on the topography of the land with consequent effects on LAN Networks. Notable are undulating landscape with pronounced physical obstructions, LAN infrastructural relocations and reconstruction, higher atmospheric dust concentration, severe ground vibrations due to blasting and the motion of heavy mine machineries. The mobile nature of mining operati-ons/practices often results in relocations of established network infrastructure such as fibre cables, repeater base stations, and mask towers (i.e. cell sites).The main reason for LAN infrastructural relocations is to ensure effective LAN/WLAN communication especially during mine expan-sions. However, this results into lengthy network downtimes. Employees' redundancies or idleness during network downtimes reduce mine productivity by about GHc2, 577, 860.64 (USD 1,288,930.32) annually. We recommend preventive maintenance schedule for all existing LAN infrastr-ucture; basic Information Communication Technology (ICT) Training into the regular training module; technically qualified Information Technology (IT) experts be part of management and finally; IT projects be planned and integrated into the annual business plan. Netronics Wireless Broadband (NWB) communication technology solutions were also recommended to management and IT policy makers in the mining companies for consideration due to its good performance in mining environments.

Keywords: information communication technology, info-rmation technology, local area network, wired/wireless local area networks, intranets/extranets, infrastructural relocations.

GJCST-C Classification: C.2.5

Strictly as per the compliance and regulations of:

Effects of Mining Operations on Local Area Networks in Large Scale Gold Mining Environments in the Western Region of Ghana

Emmanuel Effah [α] & Christian Kwaku Amuzuvi [σ]

Abstract - We investigate the impacts mining operations have on established Wired/Wireless Local Area Networks (WLANs) in mining environments in the Western Region of Ghana. Mining activities have certain immutable negative impacts on the topography of the land with consequent effects on LAN Networks. Notable are undulating landscape with pronounced physical obstructions, LAN infrastructural relocations and reconstruction, higher atmospheric dust concentration, severe ground vibrations due to blasting and the motion of heavy mine machineries. The mobile nature of mining operations/practices often results in relocations of established network infrastructure such as fibre cables, repeater base stations, and mask towers (i.e. cell sites).The main reason for LAN infrastructural relocations is to ensure effective LAN/WLAN communication especially during mine expansions. However, this results into lengthy network downtimes. Employees' redundancies or idleness during network downtimes reduce mine productivity by about GHc2, 577, 860.64 (USD 1,288,930.32) annually. We recommend preventive maintenance schedule for all existing LAN infrastructure; basic Information Communication Technology (ICT) Training into the regular training module; technically qualified Information Technology (IT) experts be part of management and finally; IT projects be planned and integrated into the annual business plan. Netronics Wireless Broadband (NWB) communication technology solutions were also recommended to management and IT policy makers in the mining companies for consideration due to its good performance in mining environments.

Keywords: information communication technology, information technology, local area network, wired/wireless local area networks, intranets/extranets, infrastructural relocations.

I. Introduction

Enterprises depend on information which must be communicated accurately, securely, and quickly. This information is often created on a myriad of hardware and software platforms, thereby increasing the difficulty for its effective and efficient exchange [1]. These rapid developments in computer technology have resulted in a greater reliance on distributed computing, typified by "client/server" [2]. Again, the increasing reliance on networks driven by the growing use of sophisticated applications has created the desire for more faster and uninterruptible network or "backbone" - WLAN/LAN. Additionally, the influx of Intranets/Extranets and the Internet technologies coerce companies to building more resilience and guaranteed networks with much reduced downtimes so they can effectively survive competition. Earlier, Network failures were much routine and unplanned for which reason downtimes were measured in days. Today, networks unavailability for even a relatively short period of time cause substantial loss to the business.

Mining companies now keenly rely on LAN for sharing information, data, and technology resources, and completely show zero tolerance for network downtimes. Thus, the long held belief that 80% of traffic remains local to the network, while 20% traverses the backbone is no longer true. In fact, there has been nearly a total reversal in LAN traffic patterns now being called "20/80 rule" [1]. The prevalence of higher intensities of dust, severe noise and vibrations due to the use of various degrees of explosives, movement of heavy mine machineries and physical obstructions at most mining environments are detrimental to the effectiveness of LANs [3-6]. The nomadic nature of mining itself also create greater hindrance to LANs' efficiency (be it wired or wireless) [7]. Normal mining practice is that, as the ore at a place gets exhausted, mining activities must relocate and hence communication infrastructure must be moved. Consequently, laid fibre optic cables, transmitting/repeaters stations must be abandoned or relocated. Line-of-sight wireless signals is obliterated due to the abrupt topological changes in landscape and "kinking" of laid fibre optic cable create sustained network downtimes. The mobility of mining operations and the subsequent relocations of the installed LAN infrastructure and the peripheral devices, and even the cost of network reconstruction create a lot of inconveniencies. The extent to which these impede the Intranets' services demands attention, because the resulting accrued network downtime cost could be too huge. The reason being that, relocation of LAN infrastructure comes with its own demerits especially if unplanned [7-8]. Relocation technicalities are always impeded; thus, getting the required expertise, resources to do it and getting the desired material. Under-utilization of LAN due to frequent

Author α σ : University of Mines and Technology, Department of Computer Science and Engineering/Department of Electrical and Electronic Engineering. Tarkwa, Ghana.
e-mails: ckamuzuvi2000@yahoo.com, ckamuzuvi@umat.edu.gh

downtimes is more expensive to organizations than when efficiently utilized [9].

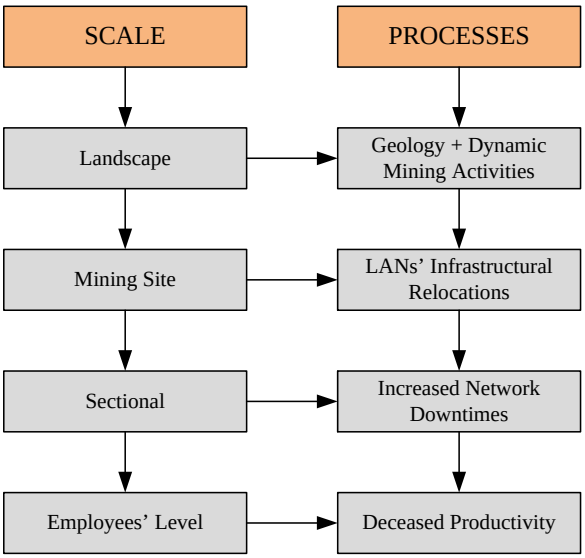

Figure 1 : Problem Structure

Mining operations are dynamic in nature. Lowlands are stockpiled to become highlands overnight and vice versa. Relocation of mine administrators' offices/workshops, mineral (gold) processing plants, fibre optic cables, repeater/transmission stations and human settlements or human communities are classic mining practices. Figure 1 presents the structure of the problem. Peculiar to this study is the way the mobile nature of mining itself and its consequent LAN infrastructural relocations affect network functionality and employee productivity. This research addresses this gap.

II. Materials and Methods

This study deployed the descriptive research method involving observations and surveys [10]. Information about the existing condition was gathered using interviews, questionnaires and observations [11]. First hand data from the respondents was collected and analysed to form the basis for the conclusions and recommendations.

The research was limited to large scale gold mining companies within the western Region of Ghana and did not test any hypothesis or quantifiable data to generalize the results. Rather, this work sought thorough information and a deep understanding [12], of the stipulated research problem [13-14]. The qualitative research approach was therefore used.

III. Results

The analysis and presentation of results were done in the order of the questionnaires viz: respondents' profile, Random LAN infrastructural relocations and LAN network effectiveness due to the mobility of mining operations, employees experience and response to network issues. The Statistical Package for the Social Sciences (SPSS) v16 and Microsoft Office Excel-2013 application software, were used in the analysis.

a) Demographic Profile of Respondents

This part of the questionnaire looked at gender, departments, and work experience with their respective companies, rank and educational background.

From the survey, it was found out that 39.3% of the respondents were females and 69.7% males which are typical of gold mining companies. Figure 2 below illustrates the graphical distribution of employees in their various departments. Respondents solely relied on the installed LAN and it accessories to execute their daily duties as employees.

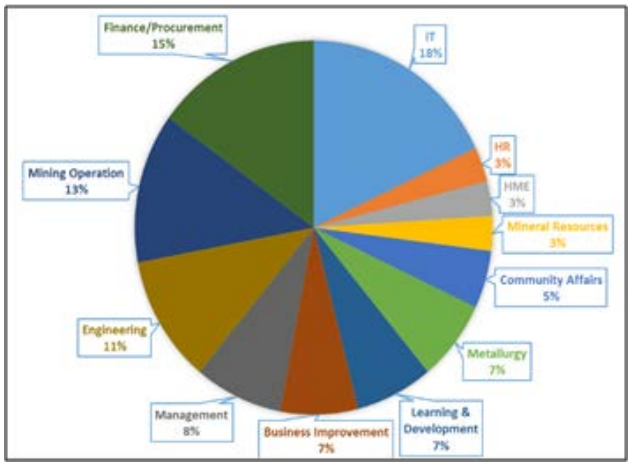

Figure 2 : Departmental distribution of respondents

Table 1 presents the Working Experience of Employees in the mine. Among the respondents interviewed, 63.9% were Senior Staffs or Managers (belonging to C3-C4 payment category), 34.4% people were supervisory staff (belonging to the C5-D1 payment category) and senior managers (belonging to the D2-D-upper payment category) representing 1.7%.

Table 1 : Years of work in the company

Years in the Mines	Frequency	Percent	Valid Percent	Cumulative Percent
Up to 5	46	75.4	75.4	75.4
11-15	2	3.3	3.3	78.7
Over 21	2	3.3	3.3	82.0
6-10	11	18.0	18.0	100.0
Total	61	100.0	100.0	

Figure 3 presents respondents Educational levels. Regarding ICT training and qualifications 26% of the employees interviewed have formal ICT training with qualifications to that effect whereas 74% do not have.

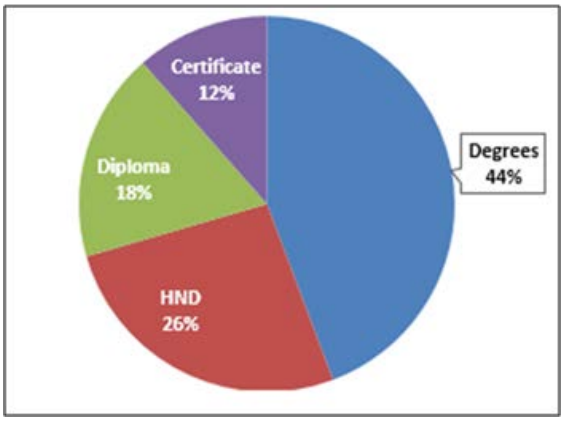

Figure 3 : Highest Educational levels of Respondents

b) Drivers for LAN Deployment

Different organizations or companies deploy ICT for different purposes. In probing why mining companies were using LAN or ICT, respondents expressed their views depending on the kind of services their respective sections or departments receive from the LAN or Intranet. Figure 4 illustrates drivers for LAN services as deployed in the mine.

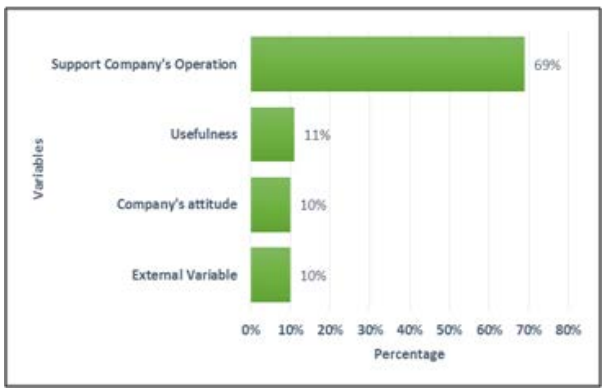

Figure 4 : Drivers for LAN Services Deployment in the Mine

c) LAN Infrastructural Relocations, Network Availability and Lost in Productivity due to Network Failures or Downtimes

It is known that, "increased LAN/WLAN network infrastructural relocations resulting in LAN/WLAN network downtimes in mining operational environment decreases mine productivity". In order to affirm this fact, questionnaires administered ascertained the lost productive hours of employees as a result of network unavailability (downtimes) and employees' experience and response to network challenges.

In order to ensure certainty and establish good grounds for results, the extent of respondents' dependency on LAN link or the Intranet or the Internet in the daily basis was explored. Per this research, 93% of the employees confirmed sheer dependence on the LAN network link availability and completely became redundant if the link was down. Averagely, this value represents more than 900 employees for a mining company. 7% however, could execute their daily duties even when the network link was down.

Reasons and impacts of LANs' infrastructural relocation were to cater for expansion and improvement in network efficiency especially when well-planned and budgeted for. However, this study shows that the unplanned relocations surpass the planned. Figure 5 summarizes the root causes of LAN infrastructural relocations. As shown in Figure 6, almost half of the population (46%) believes LAN infrastructural relocations are means to expanding the network.

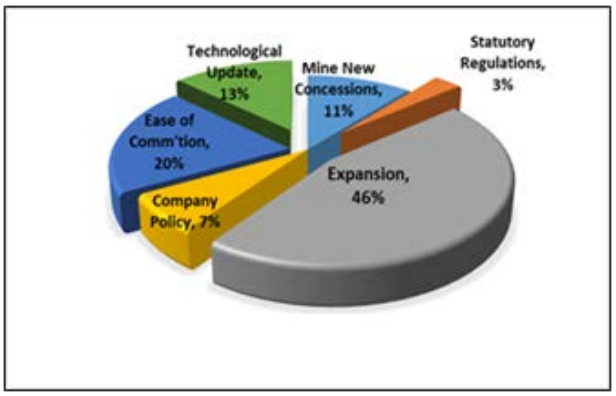

Figure 5 : Reasons for LAN Infrastructural Relocations

Figure 6 displays the impacts of LAN infrastructural relocations. Improving LAN's efficiency and minimizing interference due to noise, dust and stray frequencies from old sites are the intended impacts as subscribed by 52% of the respondents. However, the consequent reduction in LAN's efficiency due to prolonged link downtimes, increased network usability cost and maximized interference due to noise, dust and stray frequencies from new sites constitute the real impacts. 48% of the respondents alleged that the negative impacts surpass the positives.

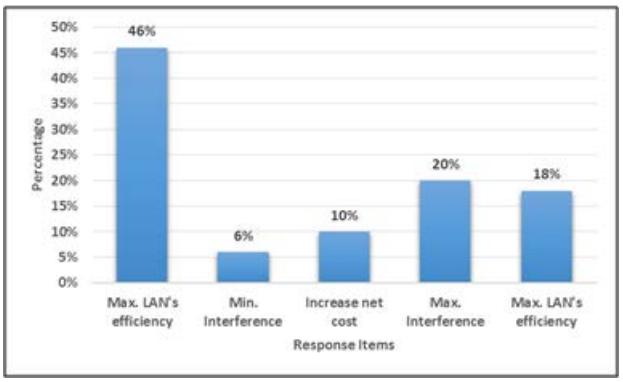

Figure 6 : Impacts of LAN Infrastructural Relocations

According to the respondents, the term "random" is frequently used to describe relocations because whenever newly explored concessions are to be mined, relocating LAN/WLAN infrastructure are considered minor tasks normally not well planned and

factored into annual budgets. In fact, LAN/WLAN relocations are done to ease Internet and Intranet communication during expansion to mine new concessions. Actually, the major intended impacts of LAN infrastructural relocations on network function and availability are to improve LAN/WLAN's efficiency and minimize interference.

The realistic and inevitable repercussions of LAN infrastructural relocations on network function and availability according to 48% of the employees include:

- Increased network usability cost due to reworks during relocations and non-alignment with existing technology.
- Maximized interference (disturbance) due to noise, dust, space and other stray frequencies at new sites.
- Reduced LAN's efficiency and hence productivity due to prolong link downtimes.

From the analysis and the above deductions from employees, causes and reasons for LAN infrastructural relocations are logical. Nevertheless, their consequent impacts on network availability, effectiveness and hence mine productivity of network-using employees is negative.

d) Productive Hours Lost through Network Downtimes

From Figure 7, employees experience rapid and sporadic network downtimes. 39% of the respondents see not less than one network downtime per day; 36% encounter not less than one network downtimes in two days; 25% experience network downtimes at least once a week. Establishing blameless baseline for logic analysis, we realized that, averagely, the network link goes down at least once in every two days.

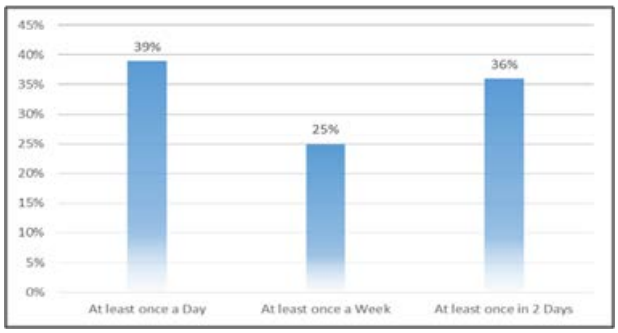

Figure 7 : Rate of Occurrences of LAN connectivity Problems

Figure 8 presents similar but at a broader perspective at the departmental level.

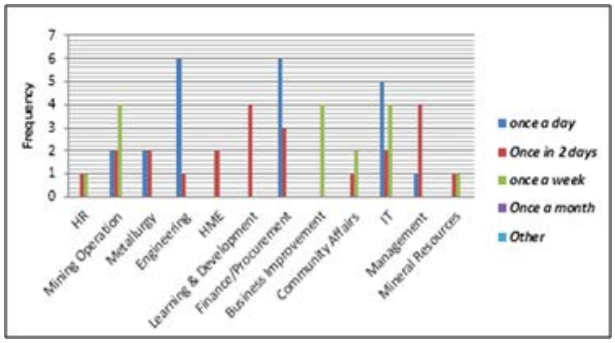

Figure 8 : Rate of LAN Network downtimes at the Departmental Level

The lengths of downtimes are illustrated in Table 2. Figure 8 shows how employees expend this time. As established from Figure 8, Table 2 extrapolates the length of downtimes averagely in two days per employee. From Table 2, 4.77 hours of productivity per an employee were lost every two days due to network downtimes. As broadly illustrated in Figure 9, more than 60% of the absolute LAN dependents waste over four productive hours every two days as a result of LAN network downtimes.

Figure10 shows that about 51% of the population do not channel their network challenges to IT desk, which can significantly delay network restoration. From Figure10, only 49% directly report their network grievances to the IT help desk.

Table 2 : Frequency Distribution of Network Downtimes

Downtime (x)	Frequency (f)	fx
4 hours	25	100
5 hours	10	50
6 hours	15	90
7 hours	5	35
8 hours	2	16
Other	4	0
	$\sum f = 61$	$\sum fx = 291$
$Average\ Downtime = \frac{\sum fx}{\sum f} = \frac{291}{61} = 4.77 Hours$		

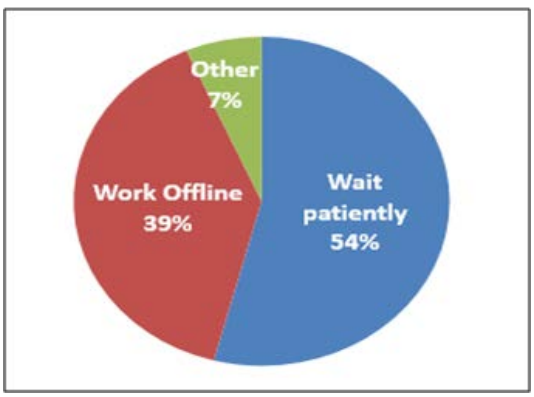

Figure 9 : What Employees do during Network Downtimes

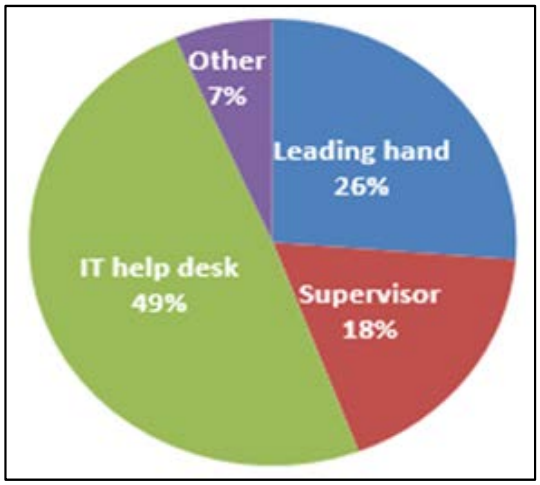

Figure 10 : Points of Contact during Network Failures or Issues

e) Downtime Deductions on Productivity or Business Operations

For the twelve Intranet/Internet-using departments selected for this research, 97% of the respondents fully rely on the network to carry out all their daily operations while 3% can operate offline. This 97% represents over one thousand employees. Again, 74% of the respondents do not have any ICT training, be it formal and informal including management.

Alarmingly, 74% of the respondents experience network failures at least once in one or two days while 26% replied at least once a week. The most vital departments forming the core of production: engineering, finance and procurement, recorded the maximum occurrences of network failures. IT department and management are the next at risk departments as far as the rate of network downtimes are concerned whilst the other departments ensue as illustrated in Figure 8.

The engineering departments leads the rate of downtimes because of their closeness to the gold processing plant, proneness to vibrations due to the plant's operation and the movement of heavy mine machineries, LAN infrastructural relocations and geography.

For the finance and procurement departments, LAN infrastructural relocations and physical obstructions accounted for their frightening network downtime rate. Averagely, the minimum length of LAN network downtimes is four (4) hours in every two days, and 54% of the respondents become idle or redundant during this time.

f) Quantification of Actual Network Downtimes Losses

On the basis of six working days in a week, the actual average weekly network downtime according to Table 2 is 14.31 hours per employee (4.77 hours in every two days). Quantifying the loss due to this network downtime for 900 employees (the minimum number proposed by the IT staff) is shown below.

An average monthly salary per employee proposed by finance departments is GHc1, 000.00. The hourly labour loss is:

$$\textit{Hourly labour loss due to network downtime} = \frac{1000}{30\,\textit{days} \times 8\,\textit{hours}} = \textit{GHc}\ 4.17$$

$$\textit{Total monthly labour loss incurred} = 4.17 \times 14.31 \times 4 \times 900 = \textit{GHc}\ 214{,}821.72$$

$$\textit{Total yearly labour loss incurred} = 12 \times 214{,}821.72 = \textit{GHc}\ 2{,}577{,}860.64$$

Note that, the estimated labour loss due to network downtimes of GHc2,577,860.64 excluded the cost of network reconstruction and stationeries due absence of the network. This loss is too high to neglect as a company, irrespective of their annual incomes.

The greatest want of the studied mining companies should be the want of in-house IT skills/experts who can effectively handle the specially-designed and mining-friendly new technologies with improved and robust LAN/WLAN network infrastructure.

IV. Conclusion and Recommendation

a) Conclusion

Over four productive hours in every two days per employee for more than 1000 employees (54%) are lost due to network failures/downtimes. This man-hour loss to talling GHc2, 577, 860.64 (USD 1,288,930.32) annually is mutely charged against productivity. Logically, it cannot be overemphasized that the amount contributes significantly to productivity loss irrespective of the company's annual profit. This affirms the fact that "increased LAN/WLAN network infrastructural relocations resulting in LAN/WLAN network downtimes in mining operational environment vis-à-vis some in-house obstacles decreases mine productivity". Mining operations are supported by software applications accessed through a network. Wired and Wireless media network connectivity enables effective communication in the mines. Thus, profitable mining operations depend on effective communication. When data network like LAN/WLAN shuts down or becomes unavailable, safety and productivity are compromised due to long employee productive hour loss. In the worst case, the entire operation must be suspended.

b) Recommendations

Pragmatically, random LAN infrastructural relocations, obstructions to line-of–sights of wireless medium of communication, attenuation in wireless information signal strength due to atmospheric dust concentrations and vibrations from numerous sources

are inevitable. Nonetheless, a better alternative must be considered.

- Against this background, the following recommendations are being made: in the short term;
- Well-planned preventive maintenance schedule for all existing LAN/WLAN infrastructure.
- Basic ICT Training modules introduced into the regular training modules for management and all employees.
- Technically qualified IT experts made part of management and business improvement department to handle pertinent IT projects and issues.
- Further research into the impact of vibration on LAN communication network infrastructure.

V. Acknowledgement

EE and CKA Thanks the University of Mines and Technology, Tarkwa, for their support. Also, the authors acknowledge the support received from Goldfields Ghana Ltd, Tarkwa and Damang Gold Mines and Anglogold Ashanti Iduapriem Mine.

References Références Referencias

1. Tanebaum, A. S. (2003).Computer Networks, Fourth Edition. Prentice Hall.
2. Collins, D., & Smith, C. (2001). 3G Wireless Networks, New York: McGraw-Hill.
3. Dajab, D. D (2006). Perspectives on the Effects of Harmattan on Radio Frequency Waves. J. Appl. Sci. Res., 2 (11): 10141018.
4. Dimari, G. A. Maitera, O. N. Waziri, M. &Hati, S. S. (2008). Pollution Synergy from Particulate Matter Sources: The Harmattan, Fugitive Dust and Combustion Emissions in Maiduguri Metropolis, Nigeria. European Journal of Scientific Research, ISSN 1450-216X Vol.23 No.3, pp.465-473.
5. Folaponmile A and Sani M. S. (2011). Empirical model for the prediction of mobile radio cellular signal attenuation in harmattan weather.
6. Breuning-Madsen, H. and T. W. Awadzi, (2005). Harmattan dust deposition and particle size in Ghana. Journal Catena (63: 1), pp 23-38.
7. Anderson, H., Hicks, T. & Kirtner, J. (2008). "The Application of Land Use/Land Cover (Clutter) Data to Wireless Communication System Design", EDX *Wireless, LLC, Eugene*, Oregon USA.
8. Ashish, S. & Prashant, J. (2010). "Effects of Rain on Radio Propagation in GSM". International Journal of Advanced Engineering & Applications, Delhi.
9. Shneiderman, B. & C. Plaisant (2010). Designing the User Interface: Strategies for Effective Human-Computer Interaction, Fifth Edition, addition Wesley Imprint.
10. Zikmund, W. G. (1994) Exploring Marketing Research, Fort Worth: Dryden Press.
11. Creswell, J. W. (1994). Research design: Qualitative & Quantitative Approaches, USA: Sage Publications.
12. Yin, R. K., (1994). Case Study Research: Design and Methods, applied Social Research Methods Series, 2nd Ed. Sage Publishing, Newbury Parl California.
13. Hair, J. F., Jr., Babin, B., Money, A. H., & Samouel, P. (2003). Essentials of business research methods. New York: Wiley.
14. Holme, I. M. & Solvang, B. K. (1991) Research Methods: Qualitative and Quantitative Methods, About Student: Lund.