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Can Implementing Smart City Technologies Save the African Cities? – Part I……6
Joseph M. Kizza – Editor-in-Chief

An Improved Palm Vein Based Recognition System …… ... ……. 9
Abikoye, Oluwakemi Christiana, Chukwu, Michael and Babatunde, Akinbowale Nathaniel

A Cost Greedy Price Adjustment based Job scheduling and Load Balancing in Grids, . …19
K Jairam Naik, A Jagan and N Satyanarayana.

Review paper on Mining Association rule and frequent patterns using Apriori Algorithm……32
Peeyush Kumar Shukla.

Unlocking the Potential of the Mobile Phones by University Undergraduate Students: a case of Sokoine University of Agriculture ……41
Mlozi , M.R.S., Mussa, M., 1Mapunda, K.M., Kalungwizi, V.J., Mwakapina,W. J., Tumbo, S. D. & Sanga, C.

TANZANIA NATIONAL FIBRE BROADBAND BACKBONE: Challenges and Opportunities ……..61
Eliamani Sedoyeka and John Sicilima,

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International Journal of Computing and ICT Research

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Can Implementing Smart City Technologies Save the African Cities? – Part I

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INTRODUCTION

Over the past year, I have taken interest and have attended one Smart Cities Innovation Summit in Austin, Texas, USA. This was also a combined a Global City Team Challenge (GCTC) and the US Ignite Application Summit. I will explain each shortly. As you will come to see, this was an opportunity of a life time for me when such convergence of innovation and community development came together. At the same Summit, there was a symposium, speaker after speaker emphasized the advantages and benefits of smart city technologies to the citizens of the community, if such technologies are implemented with care. According to Wikipedia [WIKIPEDIA], a *smart city* is an urban development vision to integrate multiple information and communication technology (ICT) and *Internet of Things (IoT)* (network of physical devices, vehicles, buildings and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data), solutions in a secure fashion to manage a city's assets – the city's assets include, but are not limited to, local departments' information systems, schools, libraries, transportation systems, hospitals, power plants, water supply networks, waste management, law enforcement, and other community services. Why big and small cities would across the global would like their cities to be classified as smart cities, you would ask? There are lots and lots of benefits, the most outstanding are building a community where there is improved quality of life for all residents through use of urban informatics and technology to improve the efficiency of services and meet residents' needs. ICT allows city officials to interact directly with the community and the city infrastructure

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and to monitor what is happening in the city, how the city is evolving, and how to enable a better quality of life [WIKIPEDIA]. Of course, the kind of technologies used in cities vary from city to city and country to country depending on the level of development. The technology you expect to find in Amsterdam, the Netherlands is not the same technology you would expect to find in Abuja, Nigeria or Nairobi, Kenya. The goal here is to be able to use the technology that is available to the city and improve the quality of life of the residents of the city.

One thing is clear, though, because of the sprawling growth of ICT and corresponding growth of smart and mobile technologies, every city now across the globe has some rudimentary but basic technologies to qualify as a smart city, depending on how that technology is used. It would be good to have advanced sensor technology, but not essential for development.

WHY DO AFRICAN CITY PLANNERS NEED TO CONSIDER SMART CITY TECHNOLOGIES

Before we talk about what is required for an African city to become a smart city, let take a look at the current characteristic of an African city.

CHARACTERISTIC OF AFRICA CITIES

To understand the characteristics of an African city, one has to understand the history of the growth of African cities. Most African cities were started by colonial powers and since then, African cities, mostly their former colonial power. In addition to that, the different political and cultural upheavals and experiences these countries have gone through post-independence, has forced the rapid growth of cities, minus planning. This explains why, the rate of growth of African cities is amongst the most rapid in the world. The concentration of African populations in cities is as much as 60% of the total population in many countries [ENDA]. In their article, "Africa's Urbanization: Challenges and Opportunities" Maria E. Freire, Somik Lall, and Danny Leipziger observe that Africa is urbanizing fast. Its rate of urbanization soared from 15 percent in 1960 to 40 percent in 2010, and is projected to reach 60 percent in 2050. They went on to say that African urban populations in Africa are expected to triple in the next 50 years, changing the profile of the region, and challenging policy makers to harness urbanization for sustainable and inclusive growth. With such expected growth most of it composed of youth with limited resources and poorly to no education, the challenge for African city planners are huge.

NEEDED TECHNOLOGIES

In their article, "From Intelligent to Smart Cities", Deakin and Al Wear have articulated factors that must be followed to turn a city into a smart city whatever the technology at hand:

- The application of a wide range of electronic and digital technologies to communities and cities
- The use of ICT to transform life and working environments within the region
- The embedding of such ICTs in government systems
- The territorialisation of practices that brings ICTs and people together to enhance the innovation and knowledge that they offer.

These are things that city planners in most major African cities can do with the technology their have at hand. These are workable and indeed some African cities like Abuja in Nigeria are doing this with the limited technologies they have and it is bearing good results.

In Part II of this article, I go into details of applying available technologies to turn your city anto a smart city and improve the quality of lives of your citizens.

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DEAKIN, MARK; AL WAER, HUSAM. "From Intelligent to Smart Cities". Journal of Intelligent Buildings International: From Intelligent Cities to Smart Cities. 3 (3). doi:10.1080/17508975.2011.586671.

An Improved Palm Vein Based Recognition System

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Abstract

Though biometrics techniques has been recording high level of security when compared with other forms of authentication, it still come with challenges of speed and accuracy of the technique been used. In this paper an improved palm vein based recognition system was developed and implemented. The development procedure was divided into four stages which are Image enhancement, Image segmentation, Image thinning and Pattern Matching. The Image was enhanced using Histogram Equalization, after which it was passed for Segmentation by K-Means algorithm. The binarized image from K-Means was then thinned using the Zhang Suen's algorithm. The Pattern Matching section of the project was done using the Euclidean Distance. Inter-distances of the intersections from the thinned image were stored in a database for subsequent matching. Results from the various test carried out showed that the system has high speed and accuracy.

Keywords: Palm vein verification, enhancement, segmentation, thinning, pattern matching

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1. Introduction

According to Chowdary, Verma and Monga (2014), authentication in use today comes in three forms: something you know, something you have and something you are. Where the first refers to authentication that utilizes tools such as passwords, and PIN (Personal Identification Number), it has been in the world scene for decades. The second refers to smart cards or tokens, these items have to be carried along. While the third type of authentication is biometrics. Biometrics has a higher level of security when compared the other forms of authentication as it cannot be lost, borrowed, stolen or forgotten.

Chowdary, Verma and Monga (2014), defined Biometric technology as a pattern recognition system which depends on physical or behavioral features for the person identification. Biometrics systems have been researched and tested for a few decades, but have only recently entered into the public consciousness because of high profile application, usage in entertainment media and increased usage by the public in day-to-day activities. Many companies are also implementing biometric technologies to secure areas, maintain time records, and enhance user convenience. Before now commonly implemented biometric modalities include fingerprint, face, iris, voice, signature, and hand geometry.

As technology advances, humans try to use these technological tools to achieve things that seemed impossible at a given time. Previously used biometric systems were based on outward physical or behavioral characteristics of an individual, but this has led to issues of porous security in terms of increased high impersonation rate as regards these technologies.

Recently, many personal authentication methods have proposed the vein patterns such as palm veins and finger veins have been used in security applications. In palm vein recognition, vital information is extracted from the internal part of an individual body- the vein, this information is

thus used for authentication purposes. Palm vein authentication has high level of authentication accuracy due to the singularity and intricacy of vein patterns of the palm (Aj-juboori, Bu, Wu, and Zhao, 2014). Unlike other biometric approaches, the palm vein patterns are difficult methods to forge because it is internal in the body.

This paper work proposes a technique for palm vein biometric verification enhancement and accuracy using statistical and data mining tools.

2. System Overview

Although, there are numerous methods already in existence for addressing the issues of palm vein recognition, the following algorithms are used are used for the system development.

- Histogram Equalization
- K-means
- Zhang Suen
- Euclidean distance

In handling image enhancement, Histogram Equalization is used while for image segmentation, K-means algorithm. Zhang Suen's algorithm is employed for thinning while Euclidean distance is used for inter-distance calculation of intersections hence handling the pattern matching aspect of the system. Microsoft C# programming language and SQL server is also used at the front and back end respectively for the implementation.

3. Related Works

In (Ahmed, Ebied, El-Horbaty, Salem, 2014), authors focused on the utilization of Homomorphic filtering for the preprocessing step which is a generalized technique for image enhancement and/or correction. The pattern matching was done using the canny edge detection filter images was gotten from CASIA Multi-Spectral Palmprint Image

In the reported work by (Kumar and Gayathri, 2014) for feature extraction and classification, the subspace learning approach using kernel principal component analysis (KPCA) was used to extracts the vessel structures by analyzing the eigenvalues of the normalized palm-vein images and also the Local mean based k-nearest centroid neighbor (LMKNCN) approach achieves the palm-vein authentication.

Aj-juboori, et.al, 2014 reported on Gabor filter for the extraction and feature reduction dimensional and matching for Palm Vein Verification.

Manocha and Kaur, 2013 discussed on using neural network palm vein recognition. The back propagation algorithm was used for the neural network implementation. The project simultaneously utilized the palm surface and palm subsurface features for identification.

In the work by Saravanan and Prabhu, 2013. The authors presented the juncture point approach and hand geometry for recognition. The junction point approach extracts palm-vein features by analyzing the junction point of the palm image.

Deepamalar and Madheswaran, 2010 used Multi-level Fusion of Multimodal Features and Adaptive Resonance Theory. Multiple Feature extraction technique was used to extracts hand shape features, Adaptive sequential floating forward search (ASFFS) was then applied for feature optimization after which pattern matching which was carried out using k-Nearest Neighbor classifier.

4. Methodology

Different algorithms have been implemented over the years for palm vein pattern recognition which have been successful. The developed system improves on the efficiency of existing system by using a simple and more efficient algorithm, paying attention to time taken for the algorithm completion and also accuracy in matching patterns.

Essential components for the system development are listed below:

a) Image Acquisition
b) Image Enhancement
c) Image Segmentation
d) Image Thinning
e) Inter-Distance Computation

4.1 Image Acquisition

Dataset used for the development and implementation were collected from the CASIA Multi-Spectral Palmprint Image Database V1.0 (CASIA database).

The Near Infrared Imaging is more tolerant to changes in environment and body condition and hence is employed in the data acquisition of palm dataset by CASIA database which is utilized in this project.

4.2 Image Enhancement

A region of Interest (ROI) of 100 * 100 is extracted from the collected dataset. The palm images collected are often blur. The image firstly has to be enhanced to increase its contrast, and make the patterns more visible. Histogram equalization is used for Image enhancement.

In histogram equalization, the input pixel intensity, x is transformed to new intensity value, x^t by T. The transform function, T is the product of a cumulative histogram and a scale factor.

$$x^t = T(x) = \sum_{i=0}^{x} n_i \frac{max\ intensity}{N} \qquad 4.1$$

where n_i *is the number of pixels at intensity i*

N is the total number of pixels in the image

4.3 Image Segmentation

The K-means algorithm is used for the segmentation stage after successful image enhancement with the histogram equalization.

The algorithm is composed of the following steps:

Let X = $\{x_1,x_2,x_3,\ldots\ldots,x_n\}$ be the set of data points and

V = $\{v_1,v_2,\ldots\ldots,v_c\}$ be the set of centers.

a) Select *'c'* cluster points randomly.
b) Compute the distance between each data point and cluster centers.
c) Assign the data point to the cluster center whose distance from the cluster centre is minimum of all the cluster centers.
d) Re-compute the new cluster center using:

$$J = \sum_{j=1}^{k}\sum_{i=1}^{x}\left|\left|x_i^{(j)} - c_j\right|\right|^2 \qquad 4.2$$

where, 'c_i' represents the number of data points in i^{th} cluster.

e) Re compute the distance between each data point and new obtained cluster centers.
f) Stop if no data point was reassigned, else repeat from step c.

4.4 Image Thinning

After segmentation is completed, the binary images obtained are now thinned to single pixel width vein patterns. This is done by using the Zhang Suen algorithm.

The algorithm operates on all black pixels P1 that can have eight neighbors. The neighbors are, in order, arranged as:

P9	P2	P3
P8	P1	P4
P7	P6	P5

Define A (P1) = the number of transitions from white to black, in the sequence P2,P3,P4,P5,P6,P7,P8,P9,P2. (Note the extra P2 at the end- it is circular)

Define B (P1) = the number of black pixel neighbors of P1. (= sum (P2…P9))

The algorithm based on [25] is given below

i) Step 1

All pixels are tested and pixels satisfying all the following conditions are just noted at this stage

- the pixel is black and has eight neighbors
- (1) 2 <= B(P1) < = 6
- (2) A(P1) = 1
- At least one of P2 and P4 and P6 is white
- At least one of P4 and P6 and P8 is white

After iterating over the image and collecting all the pixels satisfying all step 1 conditions, all these condition satisfying pixels are set to white.

ii) Step 2

All pixels are again tested and pixels satisfying all the following conditions are just noted at this stage

- the pixel is black and has eight neighbors
- (1) 2 <= B(P1) < = 6
- (2) A(P1) = 1
- At least one of P2 and P4 and P8 is white
- At least one of P2 and P6 and P8 is white

After iterating over the image and collecting all the pixels satisfying all step 2 conditions, all these condition satisfying pixels are again set to white.

iii) Iteration

If any pixel were set in this round of either step 1 or step 2 then all steps are repeated until no image pixels are so changed.

4.5 Inter-Distance Computation

Euclidean distance is employed for inter-distance computation of cross through intersections. Cross through intersection were used to reduce time taken for inter distance computation. The intersections are gotten by the following method:

1	0	1
0	1	0
1	0	1

0	1	0
1	1	1
0	1	0

For any nine pixels arranged in any of the two forms above, the coordinate of the central pixel is taken as the intersection points. The intersections are used in the computation of the inter-distance using the Euclidean distance formula.

$$D = \sqrt{(x_1-x_0)^2 + (y_1-y_0)^2} \qquad 4.3$$

where x_0, y_0 *are coordinates of the first intersection*

x_1, y_1 *are coordinates of the second intersection*

The computed inter-distances are stored in the created database.

When a test sample is brought to the system, all the previously analyzed process performed for the training set is as well performed on the test image, after which the stored inter-distances is matched with the trained one retrieved from the database to verify if it is the same palm sample.

4.6 Threshold Estimation

A threshold value of 0.7 is chosen for the matching process. This value is computed based on the pseudo code below:

```
START Process
    GET the length of the array holding the data to match with and place in A.
    GET the length of the array holding the data to verify and place in B
    COMPARE both arrays for identical elements.
    GET the number of the identical elements and place in x.
DIVIDE x by A and B
    IF the result of any division is greater than 0.7 THEN
    Return it is a Match
    ELSE
    Return it is not a match
END Process
```

A threshold value of 0.7 was choosing due to the inconsistencies present in the extraction of the Region of Interest (ROI).

5. Result and Discussion

After the training and testing images were acquired, the ROI was firstly extracted. A region of 100 * 100 was used in the development and a K-value of 5. The essence of the ROI is to separate the part that possess more feature from the image, which is then forwarded as the actual input to the system. The irregularities present in the extraction of the ROI did not affect the result since inter-distances of 2 point are the same even when read from different locations (i.e. different coordinates).

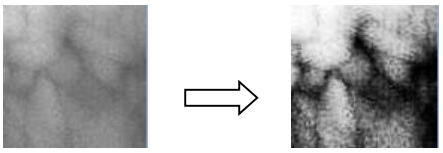


Figure 1: The image enhancement stage

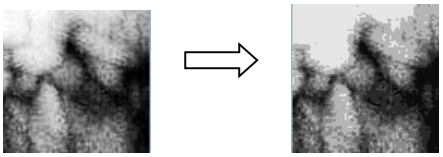


Figure 2: The segmentation stage successfully separated the image from the background.

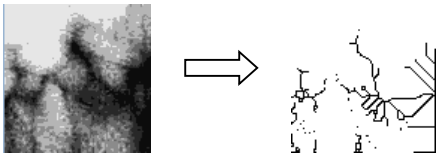


Figure 3: The binarized image which was also successfully thinned

5.1 Feature Extraction

Features of the palm vein patterns were extracted and the distance values between cross through intersection. As shown in figure

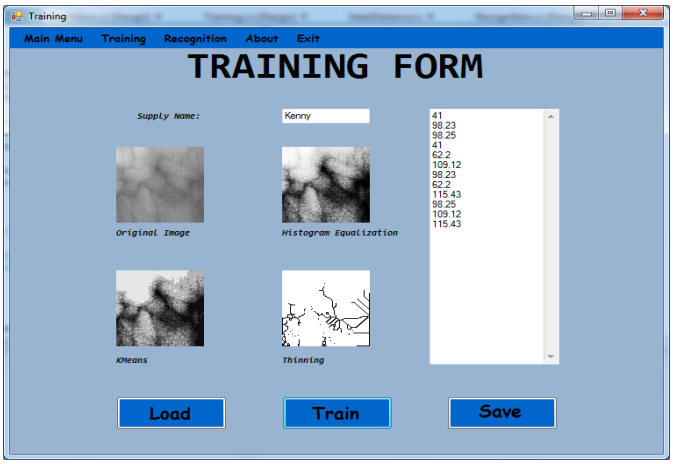


Figure 4: Interface for the Training Form

For verification, a threshold value of 0.7 is set for match due to inconsistencies in extraction of the ROI. If value is 0.7 and above a match is registered, else a mismatch.

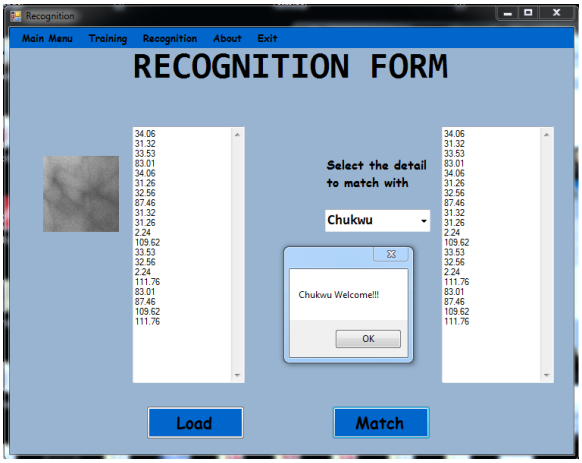


Figure 5 (a): Interface for Recognition match

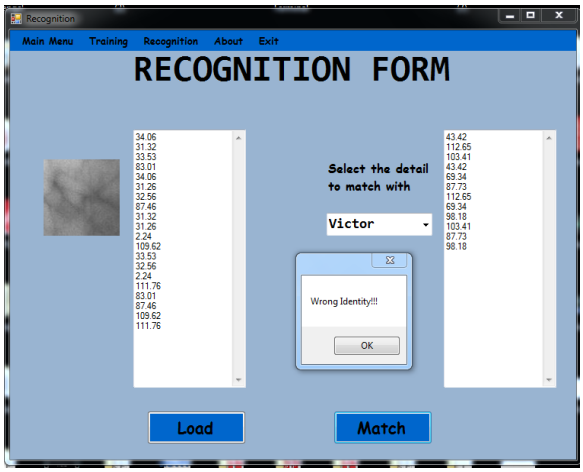


Figure 5 (b): Interface for Recognition mismatch

6. Conclusion

Biometrics system is now becoming a normal norm for enhanced security measures due to the fact that it is part of us hence cannot be forgotten or stolen. Despite its high security among other approaches, there is still a need to enhance its speed and accuracy.

The developed application was successfully tested using the CASIA database and has shown high accuracy and speed in recognition. The system has a very low dependency rate with the ROI size extracted. The system was tested with an ROI of 100 * 100 but has shown to have an increased accuracy when the region is between 150 and 220.

The work brings to light a faster system with high efficiency for good experience when addressing security.

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A Cost Greedy Price Adjustment based Job scheduling and Load Balancing in Grids

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Abstract - Balanced job scheduling in computational grids should take the motives for both grid users and resource providers into account. However, in computational grids most of existing studies on balanced job scheduling only address the motive for one party i.e. either the resource providers or the users. Motive for both parties are considered by very few studies on balanced job scheduling in computational grids. The accurate cost of the resource is one of the most attractive motives for users, which was not addressed. In this paper, we propose a balanced job scheduling algorithm which can optimizes the motive for both parties in computational grid. Benefits addressed by the proposed multi-objective optimization approach includes: (i) balanced scheduling increases successful execution rate of jobs. (ii) Minimizing the combined cost - motives for grid users. (iii) Reduce the fairness deviation of profits - motive for resource providers.

We proposed a heuristic based balanced job scheduling algorithm called as A Cost Greedy Price Adjusted Job scheduling and Load Balancing in Grids (BCGPA) to optimize the motives for both parties. The proposed approach could offer sufficient motives for both the parties, to stay and play in the computational grid by balancing jobs among the resources based on deadline and cost. Simulation result shows that: BCGPA algorithm is effective, Could lead to higher successful execution rate, smaller combined cost and lower fairness deviation compared with some popular algorithms in most cases.

Keywords: Computational Grid, Balanced Scheduling, Fairness Deviation, Success Rate, Candidate resources.

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1. Introduction

Recently, grid computing has been moving towards a pay-as-you-go model, in which resource providers expect an economic compensation for the computational services offered to the users. From the perspective of grid users, there are two major concerns in job scheduling: Exact cost incurred and Successful execution rate of jobs (SERoJ) [L. Xiao et al. 2008, H. Izakian et al 2010]. These two concerns are important since, grid users generally hope to successfully complete their submitted jobs in expected time and cost. On contrary, if jobs frequently miss their deadlines or the cost incurred is high, users tend to lose interest in the grid system and may finally leave the system. Therefore, increasing SERoJ is a motive for grid users, and so is reducing cost [I. Foster et al 2002, S.K. Garg et al 2011], which shall be considered in job scheduling.
On the other hand, from the perspective of grid resource providers, a major concern in job scheduling is *profit fairness*. Generally the providers hope to have equal opportunities to offer their resources and gain fair profits according to their properties. Therefore, increasing profit fairness, or equivalently reducing the *fairness deviation of profits*, is desirable from the perspective of resource providers [C. Xu et al 1997].

Balanced job scheduling in computational grids should consider the incentives for both grid users and resource providers. However most of the existing studies of balanced job scheduling in computing grid only address the motive for one party i.e. either the resource providers or the users. The accurate cost of the resource is one of the most attractive motives for users, which was not addressed. In this chapter, we propose a multi-objective Heuristic algorithm (BCGPA) for job scheduling in computational grid which addresses the major motives for both i.e.

1. Maximizing the SERoJ and minimizing the combined cost (motives for grid users),
2. Minimizing the FDoP (motive for resource providers).

The rest of this paper is organized as follows. Section 2 gives a review of related work on job scheduling in grid environment. Section 3 presents the system model we used. We put forward the optimization objectives for users and resource providers and propose a heuristic scheduling algorithm called BCGPA algorithm in Section 4. Simulations, results and analyses are given in Section 5 and concluded this paper in Section 6.

2. Related work

Many literatures have studied the job scheduling problem in grid environment. In general,

existing grid scheduling algorithms can be classified into two types based on *scheduling time*, i.e. Immediate mode scheduling and b) Batch mode scheduling [F. Xhafa et al. 2010] In immediate mode, a job is scheduled as soon as it arrives at the scheduler. While in batch mode, jobs are collected into a group and mapped to resources at the End of a fixed scheduling interval. The immediate mode is suitable for the situation of low arrival rate, while batch scheduling can take better advantage of job and resource information [M. Maheswaran et al. 1999]. Batch mode scheduling is commonly adopted in literatures which investigate job scheduling problem in grid environment [S. K Garg et al. 2010, S. K Garg et al. 2011 & J. Yu et al 2005].
In [K.Z. Gkoutioudi et al 2012] classified the existing heuristic based task allocation methods into several groups, such as economic heuristic, population-based heuristic, and so on. The algorithms that mainly focus on minimizing *makespan*, which is the finishing time of the latest job, without considering the budget requirement of users. In [Heyang Xu et al 2015], the authors formulate a nonlinear programming model to maximize the aggregate utilities of all grid users and propose an optimization based resource pricing algorithm. The grid user utility is defined as a function of resource units allocated to the grid user. In [Heyang Xu et al 2015], CGPA sets high priority to the jobs with few candidate resources and maps a job to the candidate with lowest cost. It adopts price-adjusting algorithm to adjust the price of candidate resources to avoid the fairness deviation becoming worse. But was not more efficient to improve SERoJ and the tendency to fail the user job is more.

In [S. K garg et al. 2011], the authors study how to decrease the aggregate cost of all jobs under some QoS requirements. They propose a constrained linear programming model and a linear programming genetic algorithm (LPGA) to minimize the combined spending of all users. Although all these approaches improve the performance, they ignore the motives for resource providers, for example, the FDoP which is considered in this paper. Huang et al. [J. Yu et al 2005] propose a series of motive-based algorithms to maximize the successful execution rate of jobs and to minimize fairness deviation among resource providers. Also, their research is based on immediate mode scheduling which is different from our work. They extend the study [L. Xiao et al. 2008], by further taking resource utilization rate and load balancing level into consideration. We tried to optimize an important motive, *combined cost*, which is most attractive to grid users however, all the above studies ignore considering job execution cost. If the cost of executing jobs is too high, grid users will lose interest in the grid system.

3. System model

Grid users are the active entities in computational grid among resource providers and grid scheduler. Grid users submit jobs to the grid scheduler with certain QoS requirements. Resource providers can offer their resources to execute jobs submitted by grid users via the scheduler. The grid scheduler is responsible for mapping the jobs submitted by grid users to the provider's resources. Grid users and resource providers interact through the grid scheduler. Here, some important QoS factors which users most concern about are budget, deadline, and the number of required successive CPU's [H. Izakian et al 2010, S. K Garg et al. 2011]. Each job consists of several tasks and each task requires one processor. Tasks of the same job should be executed concurrently on the same resource [S. K Garg et al. 2010]. The grid scheduler collects jobs submitted by grid users, gathers resource information (such as available CPUs, successive rate of the CPU, the price of using one CPU per unit time and computational speed of its CPUs) from

resource providers and sends each job to a resource to be solved in a batch mode at the end of the scheduling interval. Then, resource providers execute jobs and charge for executing them. Generally, the scenario of job scheduling is as follows: each user in the computational grid may submit one or more jobs, each job can be composed of several tasks; the grid scheduler is responsible for mapping each job to a resource to be solved.

4. Problem formation

Suppose that the computational grid consists of m ($m \geq 1$) resources; $R = (R_0, R_1 \ldots R_{m-1})$. Let R_j (a_j, p_j, s_j,, e_j) represents the resource information that meta-scheduler gathers from resource provider j ($j \in \{0, 1, \ldots, m-1\}$), where a_j is the number of available CPUs of resource R_j, p_j is price (equals to the cost of using a single CPU per second) of a CPU, s_j is the CPU speed, in million instructions per second (MIPS) and e_j is the resource success rate. Jobs that meta-scheduler collects during the scheduling interval T, is denote by $J = (J_0, J_1, \ldots, J_{n-1})$ where ($n \geq 1$). J_i (t_i, b_i, d_i, l_i, L_{ik}) represents information of the job i ($i \in \{0, 1, \ldots, n-1\}$). Where, t_i is the submitted time of job J_i ($0 \leq t_i \leq T$) and bi is the budget constraint, which means that the cost of executing job J_i must not exceed b_i, di represents the deadline by which the user desires the job to be completed. The number of tasks that job J_i contains is l_i ($l_i \geq 1$) and L_{ik} is the length of task k ($k \in \{0, 1, \ldots, l_i - 1\}$) in job J_i in terms of millions of instructions (MI).

4.1. Objectives for providers and users

A fundamental optimization objective for resource providers is the fairness of obtained profits. It means that a resource provider could obtain the same share of profit as the capacity that it invests to the system. In computational grid, each resource provider should have equal opportunity to offer its resource and gain a fair profit according to its capacity. Fairness of obtained profits is attractive to both providers with low capacity and those with high capacity. Therefore, we take *minimizing FDoP* (denoted by σ, shown in Eq. (3)) as the objective for resource providers, which is adopted in [L. Xiao et al. 2008] as well.

Let we first state several relevant definitions prior to describing Eq. (3). Each resource R_j bills for the jobs which are successfully executed by them. We use $profit_j$ to denotes the obtained profit of resource provider j, which is given by

$$Profit_j = \sum_{i=0}^{n-1} x_{ij} * \left(\sum_{k=0}^{l_i-1} \left(\frac{L_{ik}}{s_j} * p_i(1 + e_j) \right) \right) \quad (1)$$

Where, $x_{ij} = 1$, when job J_i is allocated to resource R_j; otherwise, $x_{ij} = 0$.

and $e_i = \frac{N_s}{N_s + N_f}$

Where,

Ns and N_f represents the number of jobs successes, fails the execution respectively in given deadline by the resource.

The obtained fairness of profit of resource provider j is denoted by μ_j, which is defined as the profit obtained of resource provider j divided by its total available CPU capacity, as given in Eq.

(2)

$$\mu_j = \frac{Prifit_j}{a_j * s_j} * (1 + e_j) \quad (2)$$

The FDoP for all resource providers is the standard deviation of their fairness of obtaining profit. Therefore, the optimization objective of resource providers is given by Eq. (3). Min σ = *std-dev* ($\mu_0, \mu_1, \ldots, \mu_{m-1}$)

$$= \sqrt{\frac{1}{m}\sum_{j=0}^{m-1}(\bar{\mu} - \mu_j)^2}, \quad for\ all\ i \quad (3)$$

Many objectives could be defined for grid users, but what attracts them most is that their jobs could be successfully executed at low cost and in deadline. If the cost of executing jobs is too high or jobs frequently miss their deadlines, users will lose interest in the grid system. Consequently, we endeavor to *minimize the combined cost C* (shown in Eq. (4)), which is the sum of cost of all users, and *maximize the SERoJ* (denoted by θ, shown in Eq. (5)) under the constraints of budget and deadline.

$$Min\ C = \sum_{i=0}^{n-1}\sum_{j=0}^{m-1} x_{ij} * \left(\sum_{k=0}^{l_i-1}\left(\frac{L_i}{S_j*(1+f_j)} * p_i\right)\right) \quad (4)$$

$$Max\ \theta = \frac{\sum_{i=0}^{n-1}\Psi_i}{n} \quad (5)$$

Subject to

(i) $x_{ij} \in \{0, 1\}, \forall_i \in \{0, 1, \ldots, n\text{-}1\}, j \in \{0, 1, \ldots, m\text{-}1\}$.

(ii) $\sum_{j=1}^{m} x_{ij} \le 1, \forall_i \in \{0, 1, \ldots, n\text{-}1\}$.

(iii) $\sum_{j=1}^{m} x_{ij} . l_i \le a_j, \forall_j \in \{0, 1, \ldots, m-1\}$.

(iv) $\forall_i \in \{0,1,\ldots,n\text{-}1\}$, if $x_{ij} = 1$, then $(T\text{-}t_i) + Max_{0\le k\le li-1}\left\{\frac{L_{ik}}{S_j*(1+e_j)}\right\} \le d_i$.

(v) $\forall_i \in \{0,1,\ldots,n\text{-}1\}$,if $x_{ij} = 1$,then $\sum_{k=0}^{l_i-1}\left(\frac{L_{ik}}{S_j} * p_j \le b_i\right)$.

(vi) $\forall_i \in \{0,1,\ldots,n\text{-}1\}$,for $x_{ij} = 1$, $e_i = N_s / (N_s + N_f)$ $e_i = N_s / (N_s + N_f)$; If job i is completed before its deadline, then $N_s = N_s + 1$; otherwise N_s value remains unchanged.

If job i is completed before its deadline, then $\Psi_i = 1$; otherwise, $\Psi_i = 0$. The first constraint defines the feasible range of variable x_{ij}. The (ii) Constraint ensures that a job should be assigned to no more than one resource. Constraint (iii) specifies that the total allocated CPUs on a resource should not exceed its available number. Actually, this constraint is a set of *m* constraints because for each resource there is a constraint of total allocated CPUs on it. In constraint (iv), $(T - t_i)$ means the waiting time of J_i; L_{ik} is the length of the k^{th} task of J_i; $\frac{L_{ik}}{S_j*(1+e_j)}$ is the execution time of the k^{th} task of J_i; $Max_{0\le k\le li-1}\left\{\frac{L_{ik}}{S_j*(1+e_j)}\right\}$ is execution time of J_i, Which equals to the maximum execution time among all its tasks. Therefore (iv) constraint means that, if J_i is mapped to resource R_j, then the sum of its waiting time and execution time must be less than its

deadline. Constraint (v) indicates that, if J_i is mapped to the resource R_j, then the cost of executing the job must be less than its budget. Constraint (vi) indicates, if greater the N_f value, increases the cost. Resource with higher cost has more chances to miss the deadline. Such resources are preferred less by the user and recommends price balancing.

In this paper, we deal with the job scheduling in computational grids as a multi-objective optimization problem, i.e., *minimizing the FDoP* (Eq. (3)), *minimizing the combined cost* (Eq. (4)) and *maximizing the SERoJ* (Eq.(5)). It can be noted that, when substituting Eq.(1)and (2) into Eq.(3), the first optimization objective, Eq. (3), are not linear concerning x_{ij}. Therefore, the proposed optimization problem is a nonlinear one. Moreover, from the first two constraints we can see that this problem is a combinatorial optimization problem, which has been proved to be an NP-hard problem. Due to the NP-hardness of the grid job scheduling, the approximation algorithms that suffice to find a near optimal solution are more promising. Therefore, we propose a heuristic algorithm which is presented in the next section.

4.2. Proposed BCGPA algorithm

Lots of algorithms have been developed for scheduling jobs in a computational grid. The majority of them aim to minimize the job completion time [S.K. Garg et al 2010], optimize load balance [Y. Lee, S et al 2011], or improve resource utilization [H. Izakian et al 2010]. Heuristic algorithms have shown to be useful approaches for solving varieties of hard-to-solve combinatorial and multi-objective optimization problems. Therefore, in this paper, we propose a heuristic algorithm named as *balanced cost-greedy price-adjusting* (BCGPA) *algorithm*, as shown in Algorithm 1.

Definition 1. *Candidate Resource: For job J_i, if a resource R_j can complete J_i before its deadline and the cost is less than its budget, then R_j is a candidate resource of J_i. If there is more than one candidate resource for a job, the resource with the lowest cost will be selected to handle the job.*

Algorithm 6.1: Balanced Cost-greedy Price-adjusting (BCGPA) algorithm

Input: *set of jobs (submission time, budget, deadline constraints, number of tasks, length of each task) and set of resources (num of available CPUs, CPU capacity, price of CPU, Resource success Rate).*
Output: *Mapping of jobs to resources.*

```
1   while(there is unmapped job)
2     foreach unmapped job Ji do
3       foreach resource Ri do
4         if Ri can satisfy constraints of Ji then
5           add Ri to candidate resource set Si of job Ji ;
6         end if
7       end foreach
8     if Si = Ω then
9       add job Ji to unsuccessful mapping set U;
10      change Ji 's state to failed allocation;
```

```
11      else if |Si | = 1 then
12       map job Ji to the candidate resource in Si ;
13       change the number of available CPUs of resource Ri ;
14       change i's state to successful allocation
15       end if
16     end if
17    end foreach find the candidate resource set Si (|Si| > 1)
       which contains minimal elements:
18  find the resource Ri (from Si ) which minimizes the cost of Ji;
19  map job Ji to resource Ri ;
20  change the number of available CPUs of resource Ri ;
21  change Ji 's state to successful allocation;
22  AdjustResourcePrice (Si );
23  end while
```

BCGPA algorithm is an iterative greedy approach in which, initially all jobs are set in *unmapped* state. Then, BCGPA executes the following process(lines 2–24, Algorithm 1) iteratively: First, for each unmapped

Algorithm 2: AdjustResourcePrice (Si)
Input: *candidate resource set Si ; α, β which are coefficients of increasing and decreasing price, respectively.*

job J_i, BCGPA orderly checks m resources R_0, R_1, . . . , R_{m-1} whose subscripts are randomly generated to find the candidate resources of J_i and these candidate resources compose J_i's candidate resource set S_i (lines 3-7, Algo. 1). In this process, if certain S_i is an empty set, then job J_i cannot be successfully mapped and the state of J_i is changed to *failed allocation* (lines 8–10, Algorithm 1); if certain S_i contains only one resource R_j, then BCGPA maps job J_i to resource R_j and the state of J_i is changed to *successful allocation* (lines 11–16, Algo 1).

Second, jobs for whose candidate resource set contains more than one candidate resource, BCGPA selects the job J_i whose candidate resource set contains minimal number of candidate resources and maps J_i to the candidate resource R_j in S_i which can minimize J_i's cost (lines 19–23, Algorithm 1). Then, BCGPA invokes the function of *AdjustResourcePrice* (S_i), shown in Algorithm 2, to adjust the price of candidate resources in S_i (line 24, Algorithm 1). Continue the steps mentioned above until there is no job in *unmapped* state.

Output: *calculated new price.*

```
1    foreach resource Rj in Si do
2        if Rj is the selected resource then
3            Rj .price = α × Rj .price;
4        Else
5            Rj .price = β × Rj .price;
6        end if
7    end foreach
```

As shown in Algorithm 2, for each resource R_j in S_i, if R_j is selected to execute job J_i, then the price of R_j will increase by α, which is a decimal slightly greater than 1, to avoid R_j always being selected in the following choice (lines 2–3, Algorithm 2). Otherwise, the price of R_j will decrease by β, which is a decimal slightly less than 1, to avoid R_j never being selected in the following choice (lines 4–5, Algorithm 2).

5. Simulation configurations

5.1 Simulation configurations

Assume all the users, providers and jobs are independent with characteristics shown in Table 6.1 and Table 6.2.

The initial price of all resources varies between 4G$ and 5G$ with average value of 4.5 G$. The budget allocated to each job set J_i is according to Eq. (6), it is the value of multiplying the number of jobs J_i by 500 and varied by 20%. The value 50 is obtained by multiplying the average estimated execution time (10 s) of a task by the maximal resource price (5 G$). The X is an integer variable which is uniformly distributed within the range [0, 100]. Y is an integer variable with the value of 1 or 0. Deadline requirement allocated to each job J_i is set the sum of estimated average run time and interval with 10% variation.

$$b_i = 50.l_i + X \,.\, pow\,(-1, y). \qquad (6)$$

In experiment 1, we investigate the impact of two parameters, α and β, which are used in our method. In experiment 2, we compare the proposed algorithm with other four representative algorithms to investigate the efficiency of the proposed algorithm. In experiment 3, we investigate the efficiency of the proposed algorithm under real workload traces.

Table 6.1: Grid resource characteristics

Number of Resources	1 - 4
Number of Machines	1 - 25
Number of PEs	100
PE ratings	10 or 50 MIPS
Bandwidth	1000 - 5000 B/S

5.2. Experime

Table 6.2: Scheduling parameters and their values

No. of providers	1 - 4
No. of users	200 –1500
No. of user job	200 - 500
Job length	0 – 50,000 MI
Resource price	4G$ - 5G$
I/O file size	100+(10–40%) MB

nt 1

This experiment investigates the impact of α and β on scheduling performance of our method. α and β are used in price adjusting algorithm, as shown in Algorithm 2, and they are price increasing and decreasing coefficients, respectively. We design price adjusting algorithm to improve the fairness deviation of all resource providers. In a real market, the price of certain commodity does not fluctuate largely after a deal. So, an important principle in our price adjusting algorithm is that a big change of price is inadvisable. Therefore, the pair of α and β, which change resource's price not so much, is what we want. We use average price of all resources as the metric to determine a suitable pair of values of α and β. Experiment shows the results obtained based on different pair of α and β after scheduling 100 jobs. When α = β = 1, the price of all resources has no change though the scheduling interval and the average resource is 4.47. From Experiment, it can be seen that the average price of all resources rapidly drops with β slightly decreasing. When α = 1.15 and β = 0.995, the average price is 4.19, which is the closest to 4.47 out of the results under four pairs of α and β. Thus, in experiment 2, α and β are set to 1.15 and 0.995, respectively.

5.3. Experiment 2

We compare the efficiency of Balanced cost-greedy price-adjusting (BCGPA) algorithm with other four algorithms adopted in related researches to investigate it i.e., min-min cost time trade-off (MinCTT) algorithm], modified min cost (MMC) algorithm, linear programming based genetic algorithm (LPGA) and CGPA, with varied system load ranging from 0.41 to 0.99. The system load is calculated by Eq. (7).

$$System_{load} = \frac{\sum_{i=0}^{n-1}\sum_{k=0}^{l_i-1} L_{ik}}{interval*\sum_{j=0}^{m-1} a_j*s_j*(1+e_j)} \quad (7)$$

Submission time and then dispatches each job to a candidate resource. If a resource can satisfy a job's QoS requirements, the resource is a candidate resource for the job. If a job has no candidate resource, the job fails to be scheduled and if there are many candidate resources, the one with the lowest cost will be selected. MinCTT algorithm maps each job to the resource with minimizing the cost metric, which is defined as the trade-off between response time and execution cost. MMC algorithm handles the jobs in two ways: for jobs with one candidate resource, their mapping is frozen and the jobs with more than one candidate resource will be mapped to the most economical resource. LPGA use genetic algorithm to generate a solution near to optimal solution, by seeding the approximate solutions from MMC. In the following parts, we compare these algorithms with our approach on three considered factors: SERoJ, combined cost and FDoP.

5.3.1. Successful execution rate of jobs (SERoJ)

A successful job execution means that a job is completed before its deadline. With higher successful execution rate, the grids provide more interest the users have in performing their jobs. The SERoJ is calculated according to Eq. (5). As shown in experiment and Fig. 1, the SERoJ obtained by all algorithms decreases with the increase of system load. LPGA has the highest successful execution rate, and the result of our proposed algorithm, BCGPA, is very close to that

of LPGA and outperforms the other three methods. That is because BCGPA preferably maps the job with tight QoS constraints (lines 11–21, Algorithm 1). Thus, all jobs will be more likely to be mapped to a resource to be completed before its deadline.

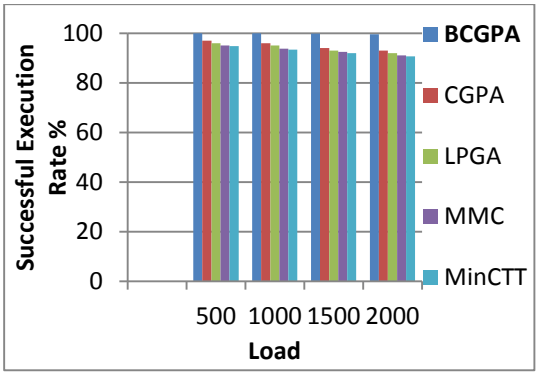


Fig. 1. Successful execution rate of jobs with different system loads.

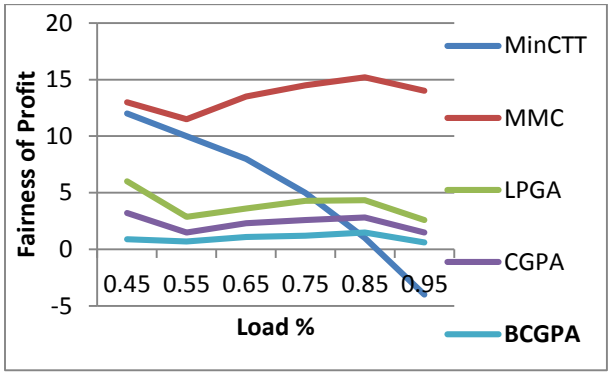


Fig. 2. Fairness deviation obtained by varied Algorithms with varied load.

5.3.2. Combined cost

According to Eq. (4) Combined cost is calculated, which is the total cost of all successfully mapped jobs. The comparison results of the proposed BCGPA algorithm with other four algorithms are shown. BCGPA algorithm obtains lower combined cost than that obtained by other algorithms in all varied system load situations because BCGPA tries to map a job to the candidate resource with the lowest cost (lines 20–21, Algorithm 1). Although FCFS can obtain relatively low combined cost, its job failure rate is higher than other methods. We use *cost saving ratio* (*CSR*) to elaborate how much combined cost that users can save by using the proposed BCGPA algorithm. The *cost saving ratio* is defined as the difference of combined cost between selected algorithm and the proposed BCGPA algorithm divided by the combined cost obtained by BCGPA algorithm.

For example, the cost saving ratio of MMC algorithm is calculated by Eq. (8). A positive value of certain CSR indicates that BCGPA algorithm obtains lower combined cost than the corresponding algorithm; otherwise, BCGPA algorithm brings higher combined cost than the corresponding algorithm. For example, when system load is 0.45, the value CSR MMC is about 13%, which means that the proposed BCGPA algorithm can save combined cost by 13% compared with that obtained by MMC algorithm. From Fig. 2, it can be seen that the cost saving ratio obtained by the other four algorithms is bigger than zero in most cases except the MinCTT algorithm with system load 0.95. That is because when system load is 0.95, many jobs fail to be mapped to a resource and these jobs produce no execution cost in MinCTT algorithm.

$$CSR_{CGPA} = \frac{\text{combined cost obtained by CGPA} - \text{combined cost obtained by BCGPA}}{\text{combined cost obtained by BGPA}} \qquad (8)$$

5.3.3. Fairness deviation of profits

The fairness of grid can be expressed in the way that all resource providers have equal opportunities to offer their resources and can obtain fair profits according to their resource capacities [L. Xiao et al. 2008]. FDoP (defined by Eq. (3)) indicates the dispersion of all resource providers' profits. The smaller the value of fairness deviation is, the fairer the providers' profits are. Fig. 3 show the results obtained by different algorithms under different system loads. It can be seen that our approach obtains lower fairness deviation than that of other four methods. The reason is that to adjust the price of all candidate resources for each job mapping the proposed CGPA algorithm uses price adjusting algorithm. If a candidate resource obtains a job, then the CGPA algorithm slightly increases its price to prevent it from always being selected in following mapping (lines 2–3, Algorithm 2); otherwise, the CGPA algorithm slightly decreases its price to avoid never being selected in following mapping (lines 4–5, Algorithm 2).
Thus, the proposed CGPA algorithm can get better fairness deviation. Also, from Fig. 3, we can find that the fairness deviation obtained by all approaches declines with the increasing of system load. The reason lies in that, with the increasing number of jobs, more and more resources get jobs near to their processing capacities, which leads to the decrease of fairness deviation.

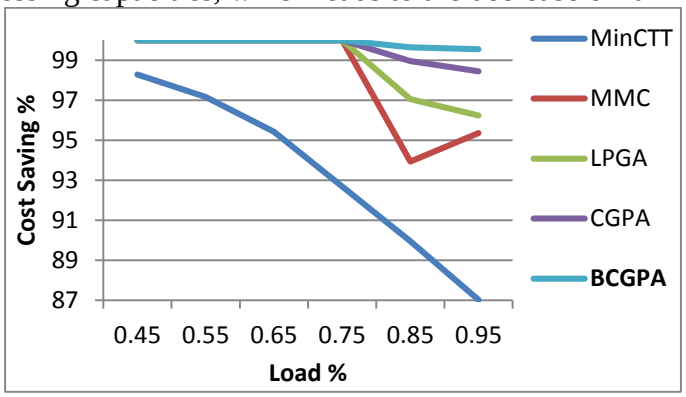


Fig. 2. Cost saving rate obtained by the four algorithms.

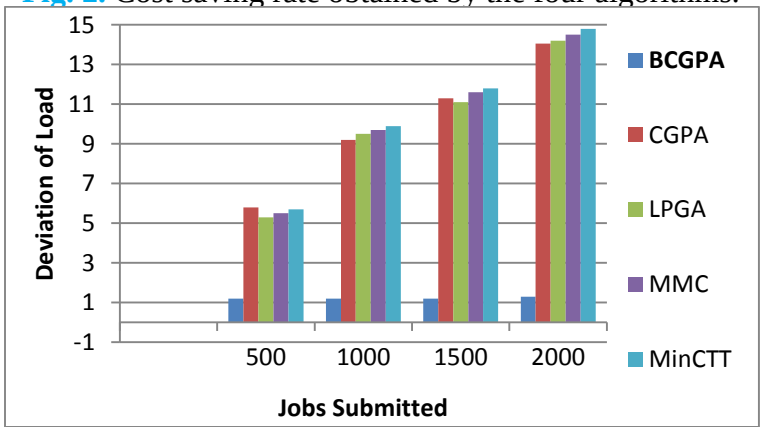


Fig. 4. Fairness deviation of Load**.**

6. Conclusion

The two important entities in computational grid are Grid users and resource providers and they have different objectives of interest and make autonomous scheduling decisions. This makes the problem of job scheduling more complex than ever before in commodity market-like grid.

In this paper, job scheduling is formulated in computational grid as a multi-objective optimization problem. It is called as a well-known NP-hard problem due to its combination property. So a heuristic, *balanced cost-greedy price-adjusting* (BCGPA) *algorithm* is proposed. In each mapping, BCGPA algorithm sets high priority to the jobs with few candidate resources and maps a job to the candidate with the lowest cost and then adopts a price-adjusting algorithm to adjust the price of candidate resources to avoid the fairness deviation be-coming worse. The simulation results clearly illustrate that our approach is efficient and could lead to a higher successful execution rate, lower combined cost and better fairness of providers' profits than other compared algorithms in most cases.

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Review paper on Mining Association rule and frequent patterns using Apriori Algorithm

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ABSTRACT

Because of speedy development at worldwide information several mining algorithms have been developed over the years. Apriori Algorithm is one of the most productive algorithm which is used to excerpt frequent patterns from huge database likely tera and penta bytes of data and find out the appropriate association rule for distinguish the knowledge. It basically needs two important things: minimum support and minimum confidence. Firstly, we check whether the frequent item are greater than or equal to the minimum support threshold value and we find the frequent item sets respectively. Secondly, the minimum confidence constraint is used to generate association rules according to the minimum confidence threshold value. In this paper we propose an algorithm (Apriori) used to mine the frequent patterns and association rules. The Apriori algorithm generates candidate set during each step. It abbreviates the item sets by dispose the infrequent item sets that exactly not match the minimum threshold from the candidate sets. To avoid the propagation of candidate set which is expensive the FP Growth algorithm is used to mine the item set. The FP Growth does not generate the candidate set instead it generates an optimized data set that is FP tree from the dataset.

Keywords: Data mining, Association rules, frequent item sets, Apriori algorithm, minimum support, minimum confidence.

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1.INTRODUCTION

Frequent patterns are patterns like as item sets, subsequences or substructures that come along in a data set subsequently. Behalf of the transactional database, we can suppose the behavior of the products purchased by the customers. For example a set of items Mobile and Sim card that appear frequently as well as together in a transaction set is a frequent item set. Subsequences means if a customer buys a Mobile he must also buy a Sim card and then head phone etc. From the overall structure of the database these transactions are occurs sequentially is called sequential patterns. The Substructure is concerned to different structural forms such as sub graphs, sub trees which may be manipulate along with item sets or sequences.

Data mining is manipulated to work with amount of data stored in the database, to take out the required information and knowledge [1]. Data mining has various strategies to perform data extraction. Association proficiency is the most effective data mining technique among them. It encounters concealed or craved pattern among the huge amount of data. It is also responsible for finding co-relationships among different data attributes in a large set of items in a database. Since its introduction, this method has acquired lot of attention. Author of [1] has examined that an association analysis [5] is the research of hidden pattern or clause that occur repeatedly common in an applied dataset. Association rule acquire relations and interconnection among data and datasets given. Such association's rules are calculated from the data with help of the concept of probability.

1.1. Basic Concept: The main approach is to finding association rules to interrupt the problem in two parts:

a. Find all frequent item sets

b. Generate strong association rules from frequent items.

Finding all frequent item sets is a difficult task where generating strong association rules are not too much costly.

The problem of association rule mining from frequent items is defined as:

Let $\boldsymbol{X} = \{\boldsymbol{x_1}, \boldsymbol{x_2}, \ldots\ldots\ldots\ldots \boldsymbol{x_n}\}$ be a set of n binary attributes called *items*.

Let $\boldsymbol{Y} = \{\boldsymbol{y_1}, \boldsymbol{y_2}, \ldots\ldots\ldots\ldots \boldsymbol{y_n}\}$ be a set of transactions called the *database*.

Each transaction in $\boldsymbol{Y}$ has a specific transaction ID and contains a subset of the items in $\boldsymbol{X}$.A rule is defined as an implication of the form:

$$A \rightarrow B$$

An example rule for the supermarket could be **{tea ,sugar→ milk}** meaning that if tea and sugar are bought then customer also buy milk.

2. APRIORI ALGORITHM

The algorithm [5] is designed to find associations in sets of data in a database. Apriori is a definitive algorithm for learning association rules. Apriori is designed to operate on databases containing transactions (for example, collections of items bought by customers, or details of a website frequentation).Apriori uses breadth-first search and a tree structure to count candidate item sets efficiently. It generates candidate item sets of length k from item sets of length $k - 1$. Then it prunes the candidates which have an infrequent sub pattern. According to the downward closure lemma, the candidate set contains all frequent k-length item sets. After that, it scans the transaction database to determine frequent item sets among the candidates. Candidate generation generates large numbers of subsets (the algorithm attempts to load up the candidate set with as many as possible before each scan). Bottom-up subset exploration (essentially a breadth-first traversal of the subset lattice) finds any maximal subset S only after all $2^{|S|} - 1$ of its proper subsets.

2.1. ITEMSET

Item set is collection of items in a database which is denoted by D= {x1, x2,……..…,xn},Here 'n' is the number of items.

2.2. CANDIDATE ITEMSET

Candidate item sets are items which are only to be considered for the processing. Candidate item set are all the possible combination of item set. It is usually denoted by 'Ci' where 'i' indicates the i-item set.

2.3. TRANSACTION

Transaction is a database entry which contains collection of items. Transaction is denoted by and **T**⊆D.
A transaction contains set of items T= {x1, x2, ……., xn}.

2.4. MINIMUM SUPPORT

Minimum support is basically condition which should be satisfied by the given items so that further processing of that item can be completed. Minimum support can be considered as a condition which helps in removal of the in-frequent items in any database. Usually the Minimum support is given in terms of percentage.

2.5. FREQUENT ITEMSET

Frequent item set is commonly large item set i.e. the item sets which satisfies the minimum support threshold value are known as frequent item sets. It is usually denoted by 'Li' where 'i' indicates the i-item set.

2.6. CONFIDENCE

Confidence indicates the certainty of the rule. This argument lets us to count how often a

transaction's item set couple with the left side of the implication with the right side. The item set which does not satisfies the above condition can be discarded. Consider two items X and Y. To calculate confidence of X->Y the following formula is used, Conf(X->Y) = (number of transactions containing both X& Y) (Transactions containing only).

3. LITRATURE REVIEW

Various algorithms for mining association rules and frequent patterns from relational database have been done since long before. Association rule mining was first presented at 1993 by Rakesh Agrawal[3], T. Imielinski, and A. Swami [3].After sometime the Boolean Association rule of mining frequent item set is proposed by Srikant in 1994.The core principles of this theory are the subsets of frequent item sets are frequent item sets and the supersets of infrequent item sets are infrequent item sets. This theory is regarded as the most typical data. A new implementation of mining of frequent closed item set is introduced by Pasquier in 1991. Further a new approach is published for mining of maximum frequent item set by Bayarado,1998.At last Srikant again evaluate some improvements in mining Fuzzy association rules in1996.
Association rule mining proceeds on two main steps. The first step is to find all item sets with adequate supports and the second step is to generate association rules by combining these frequent or large item-sets [8][9][10]. In the traditional association rules mining [2][4], minimum support threshold and minimum confidence threshold values are assumed to be available for mining frequent item sets, which is difficult to be set without specific knowledge; users have difficulties in setting the support threshold to obtain their required results. To use association rule mining without support threshold another constraint such as similarity or confidence pruning is usually introduced.

4. PROPOSED ALGORITHM

Association rule mining is an important task in data mining. Association rules are frequently used by retail stores to assist in marketing, advertising, floor placement and inventory control. In analyzing market basket analysis, people often use Apriori Algorithm, but Apriori generates large number of frequent item sets.

Algorithm for Apriori algorithm:

Apriori (T, ε)

$L_1 \leftarrow \{$*large 1-itemsets that appear in more than* ε*transactions* $\}$

$k \leftarrow 2$

while $L_{k-1} \neq \varnothing$

$C_k \leftarrow$ *Generate*(L_{k-1})

for transactions $t \in T$

$C_t \leftarrow$ Subset(C_k,t)

for candidates $c \in C_t$

$\text{count}[c] \leftarrow \text{count}[c] + 1$

$L_k \leftarrow \{c \in C_k | \ \text{count}[c] \geq \varepsilon\}$

$k \leftarrow k + 1$

return $\bigcup_k L_k$

Let me give you an example to explain it. Suppose you have records of large number of transactions at a shopping center, Wall-mart, showrooms etc. as follows: The Transaction id and sales item details are following:

Transaction ID	**Items Purchased**
T1	{Mango, Orang, Namkeen, Kit Kat, Eggs, Burger}
T2	{Dahi, Orange, Namkeen, Kit Kat, Eggs, Burger}
T3	{Mango, Apple, Kit Kat, Eggs}
T4	{Mango, Ugli, Corn, Kit Kat, Burger}
T5	{Corn, Orange, Onion, Kit Kat, Ice-cream, Eggs}

Now, we follow a simple golden rule: we say an item set is frequently bought if it is purchased at least 60% of times. So for here it should be bought at least 3 times.

Transaction ID	**Items Purchased**
T1	{M, O, N, K, E, B }
T2	{D, O, N, K, E, B}

T3	{M, A, K, E}
T4	{M, U, C, K, B }
T5	{C, O, O, K, I, E}

Step 1: Count the number of transactions in which each item occurs, Note "O=Orange" and "O=Onion" is bought 4 times in total, but, it occurs in just 3 transactions.

Step 2: Now remember we said the item is said frequently bought if it is bought at least 3 times. So in this step we remove all the items that are bought less than 3 times from the above table.

Item	Number of transactions
M,O,B	3
E	4
K	5

This is the single items that are bought frequently. Now let's say we want to find a pair of items that are bought frequently. We continue from the above table (Table in step 2)

Step 3: We start making pairs from the first item, like MO,MK,ME,MB and then we start with the second item like OK,OE,OB. We did not do OM because we already did MO when we were making pairs with M and buying a Mango and Onion together is same as buying Onion and Mango together. After making all the pairs we get,

Item Sets
MO,MK,ME,MB,OK,OE,OE,OB,KE,KB,EB

Step 4: Now we count how many times each pair is bought together. For example M and O is just bought together in {M,O,N,K,E,B}.While M and K is bought together 3 times in {M,O,N,K,E,B}, {M,A,K,E} And {M,U,C, K, B}

After doing that for all the pairs we get-

Item Sets	Number of transactions

MO	1
ME,MB,OB,EB	2
MK,OK,OE,KB	3
KE	4

Step 5: Golden rule to the rescue. Remove all the item pairs with number of transactions less than three and we are left with.

Item Pairs	Number of transactions
MK,OK,OE,KB	3
KE	4

These are the pairs of items frequently purchased together. Now let's say we want to find a set of three items that are brought together. We use the above table (table in step 5) and make a set of 3 items.

Step 6: To make the set of three items we need one more rule (it's termed as self-join).It simply means, from the Item pairs in the above table, we find two pairs with the same first Alphabet, so we get

· OK and OB, this gives OKB

· KE and KB, this gives KEB

Then we find how many times O,K,E are bought together in the original table and same for K,E,B and we get the following table

Item Set	Number of transactions
OKE	3
KEB	2

While we are on this, suppose you have sets of 3 items say PQR, PQS, PRS, PRT, QRS and you want to generate item sets of 4 items you look for two sets having the same first two alphabets.

· PQR and PQS -> PQRS

· PRS and PRT -> PRST

And so on … In general you have to look for sets having just the last alphabet/item different.

Step 7: So we again apply the golden rule i.e. the item set must be purchased together at least 3 times which leaves us with just OKB, Since KEB are bought together just two times .Thus the set of three items that are bought together most frequently are O,K,E.

5. CONCLUSION

This paper is an attempt to use data mining as a tool used to find the frequent pattern and its association rule of different item sets. An Apriori Algorithm may play an vital role for finding these patterns from huge database so that various sectors can make better business decisions especially in the retail sector. Apriori algorithm may find the tendency of a customer on the basis of frequently purchased item-sets. There are wide range of industries have deployed successful applications of data mining. Data mining in retail industry can be deployed for market campaigns, to target profitable customers using reward based points. The retail industry will gain, sustain and will be more successful in this competitive market if adopted data mining technology for market campaigns.

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Unlocking the Potential of the Mobile Phones by University Undergraduate Students: a case of Sokoine University of Agriculture

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Abstract

Literature show that use of mobile phones is omnipresent and pervasive in developing countries, especially among the youth. This study was carried out to assess the academic benefits of owning and using mobile phone among the undergraduate students at Sokoine University of Agriculture in Tanzania. Specifically, the study assessed the type of people students communicate to, preferred people and preferred period of the day and also the type of information that is communicated, and when mobile phones are inactivated. Students were randomly sampled from all departments. The study involved semi-structured questionnaires, and 302 undergraduate students who were randomly sampled from various degree programmes participated. The study found that most students prefer to communicate to their mothers and most of the communications are done from late evenings. Family issues were mostly communicated on mobiles phones. Further, the study found little use of mobile phones in academic issues. The study recommends that the University should educate newly enrolled students on proper use of mobile phones, with the view of using mobile phones in academic-related issues.

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Introduction

The use of mobile phones communication device has rapidly increased since the commercialization of mobile phones technology by Motorola in early 1980s (Harman & Sato, 2011). Mobile phones are one of the most common information access devices with almost 31% of the global population having access (Sayan, 2006; Sanou, 2013). Mobile phone technologies are now in the hands of almost 31% or 2 billion people of the 6.47 billion people on this planet ("Population Reference Bureau Statistics", 2006; Motorola, 2006; Sanou, 2013). The penetration of these technologies is increasing very rapidly with around 779 million (Gartner Press Release, 2005). Mobile phones are sold every year and were expected to reach over 1 billion units per year in 2009 (Gartner Press Release, 2005). The Pew Research Center (2013) reported that USA with a population of 307 million people, 70.1% of its people owned mobile phones in 2012, and lowered to 52.7% in 2013 (Smith *et al*., 2011). And an earlier study in 2010 found that of 246 tracked undergraduate students, 96% owned cell phones. These staggering numbers are indicator of the growth and reach of mobile phones. As 75 percent of the world's mobile subscriptions are in developing countries, studies of patterns of use of mobile phones are essential in broadening our understanding (Pearce, 2013).

Mobile phones have an intrinsic social impact by the way the technologies emphasize portability and constant communication. The portable nature of this communication medium means that it is often used in public spaces. Mobile phones today go beyond just voice communication and provide a multitude of other features and services including text messaging (SMS), multimedia messaging (MMS), photo display and recording, video playback and recording, calendaring, etc. Townsend (2002) argues that the diffusion of the mobile phone was among the fastest of any technology in history. Such a rapidly evolving and wide spread communication technology and medium has important social contexts and implications. The significance of the mobile phone lies in empowering people to engage in communication, which is at the same time free from the constraints of physical proximity and spatial immobility (Hans, 2004).

Nowadays, modern technology develops so rapidly that people can hardly catch up with its pace (Sife, Lwoga, & Sanga, 2007). There is no doubt that mobile phones, as a new industry of modern technology, have got into people's life. As sensitive reflectors of information, more and more mobile phone users have appeared in the campus everywhere (SM, 2012). While some students are enjoying whatever mobile phones have brought to us, there are others who stand against it. According to SM (2012), the main benefits of mobile phones in university are as follows: firstly, there is no denying the fact that mobile phones have made campus life more convenient. A survey found that mobile phones are becoming part of university life and 99.7% of students use their own mobile phones to communicate with others (Ransford, 2009). As it can be seen, mobile phones provide students with a fast and convenient way of communication, such as getting in touch with schoolmates and hunting for jobs, which was previously unimaginable. Secondly, instead of going to the PC lab and finding computers to look for news on current events, students can use mobile-network to search the Internet. It is by this means that university

students can broaden their horizon and enrich their minds. Furthermore, with the help of mobile phones, students can do work more efficiently. For example, Hans (2004) quoting Palen, Salzman and Youngs (2001) says that more and more, mobile phones invade daily routine behavior of all kinds, and there is an increase in "grooming calls" which have primarily a non-instrumental, socio-emotional function: for example, showing concern, solidarity and commitment, and articulating nearness, compassion, sympathy and love. Lastly, with the help of mobile phones, students can do work more efficiently.

Many students in university treat mobile phones as electronic dictionary and a chatting device with teachers for academic purpose. They share useful information related to their lessons and solve academic problems (SM, 2012). In this way, mobile phones not only can save students' time and energy, but also help with them in their studies. However, the negative effects are also obvious. Above all, more and more university students are indulged in online chat and online games, which make them weak in studies. Moreover, some even use mobile phones to cheat in examinations. Hans (2004) quoting Ram and Jung (1990) says that in a quantitative perspective, the simple concept "amount of cell phone usage" results in a multidimensional construct unfolding on at least three independent axes: 1) Usage intensity: which refers to "how often the product is used (usage time) regardless of the different applications for which the product is used." 2) Usage breadth: referring to the number of partners to whom calls are directed and from whom calls are received; and 3) Usage variety, measuring the "different applications for which a product is used or the different situations in which a product is used, regardless of how frequently it is used" .

Chakraborty (2006) study of 100 university students in India (50) and the U.S.A (50) suggested that overall students in India used mobile phones differently from their American counterparts. The researcher concluded that in a developing market like India, mobile phones may be the primary and only phone to which students had access. Some of Chakraborty (2006) study findings included most of the respondents indicating that they owned and used mobile phones to stay in touch with family and friends, and the need to use in case of emergency or personal safety. Yet twenty five percent of students in India indicated that the most important reason for acquiring a mobile phone is for emergency. Further, Chakraborty (2006) study found that a large percentage of respondents (70% from India and 66% from the U.S.A) kept their phones in mute / vibrate mode while attending classes, similar 22 figures (70% from India and 60% from the U.S.A) were disclosed for a movie or concert scenario. Some respondents noted that they kept their phones in mute / vibrate mode while in a meeting. The respondents from both India and the U.S.A indicated that they used phones more in the evening than any other time of the day (76% and 86% respectively). The least used time of the day was morning with only 44% and 48% responses from India and the U.S.A respectively.

Studies on the impact of using a cell phone while driving or simultaneously engaging in other motor activities of a similar nature are common (Strayer, Drews, & Johnston, 2003; Drews, Pasupathi, & Strayer, 2008; Charlton, 2009; Hyman *et al*., 2010), but research investigating the influence of cell phone use in other domains is surprisingly sparse. One area of particular interest which seems underrepresented in the literature regarding cell phones use is the impact of this communication device in academic settings.

Harman and Sato (2011) quoting Nielsen Wire (2010)indicated that the analysis of data gathered in the U.S.A by the Nielsen Company revealed that young adults aged 14-18 exchange an

average of 1,630 text messages per month, or approximately 54 messages per day. Additionally, in regards to cell phones use in educational settings, Herman and Sato (2011) quoting Pew Internet (2010) in the U.S.A. wrote that in spite of the fact that many schools prohibit the use of cell phones, 65% of students who attend schools that ban cell phones, still brought them every day and 43% of students reported that they used to text messages in class at least once per day.

Mobile phones in Africa

Cell phones today are nearly ubiquitous in African society (Aker & Mbiti, 2010). Teenagers and young adults are obsessed by them, carrying them around everywhere. This is the first generation to have direct access to high technology. The World Bank and African Development Bank report that there are 650 million mobile users in Africa, surpassing the number in the United States or Europe (Aker & Mbiti, 2010; Sanou, 2013). In some African countries more people have access to a mobile phone than to clean water, a bank account or electricity (Sambira, 2009; Aker & Mbiti, 2010). In Sub-Saharan Africa especially, three out of four subscriptions were done by cell phones users. This is the highest ratio of mobile to total telephone subscribers of any region in the world (Sanou, 2013). People in Africa are using mobile phones for everything: communicating, listening to the radio, transferring money, shopping, mingling on social media and more (ITU, 2004; Sanou, 2013)

Researchers have outlined many reasons for using and for rapid spreading of mobile phones in Africa (Aker & Mbiti, 2010). The major reason as indicated by Alzouma (2006) is that mobile phone fit better in the African domestic environment; in the sense that it is in accordance with the mental dispositions of illiterate people. With cell phones, Africans can speak their own languages with the full emotional content and the rational, the logic of verbal communication between themselves and others. Other reasons are such as mobility and security. Also one can work using the radio spectrum, as such there is no need to rely on physical infrastructure; it requires only basic literacy, and therefore, mobile phones are accessible to a large segment of the population, allowing for the transfer of data, which can be used in the context of applications for the purposes of health, education, commerce or governance. Finally, due to factors like increased private sector competition and innovative payment methods (e.g. pre-paid method), mobile phones are increasingly affordable to a larger part of the population (Donner, 2006; Economist, 2008, Sambira, 2009; Rashid & Elder, 2009).

As mobile phone penetration rates increase rapidly in developing countries, there has also been an increase in the extent of research on mobile phone usage (Sife *et al*., 2010; Sanga *et al*., 2013; Sanga *et al*., 2014). In general, studies have focused on different aspects of the adoption and use of mobile phones. Most of the findings from these studies put mobile phones as important tool for community development in the developing countries. However, there is still a lack of evidence of usage of mobile phones as a tool to solve development problems, mainly due to the difficulty in measuring their social and economic impacts (Rashid & Elder, 2009). To understand Africa's digital opportunity, one has to look at the numbers: six out of the 10 fastest-growing economies are in Sub-Saharan Africa (Aker & Mbiti, 2010). Africa is the second-biggest mobile market in the world — smartphones outsell computers four to one. Significant opportunities exist here to use social media in business (Aker & Mbiti, 2010).

Mobile phones use in Tanzania

The use of mobile phones in various sectors in Tanzania for different purposes has been reported by many previous studies (Ringo & Busagala, 2012; Sanga *et al*., 2013; Venkatakrishnan & Ngilangwa, 2013; Bhalalusesa, &Arshad, 2014,Sanga *et al*., 2014, Shao &Seif, 2014; Mahenge & Sanga, 2016, Mtebe, 2016). Mtega *et al.*, (2012) explored the use of mobile phones by undergraduate students at Sokoine University of Agriculture; Morogoro, Tanzania for teaching and learning purposes and found that majority of the respondents used their mobile phones for teaching and learning process. It was found that most respondents reported to use conventional mobile learning applications including text messages and phone calls. Only few respondents from teaching staff and students had smart phones with a number of m-learning applications. These were able to create, upload, download and share academic resources through their smart phones while others recorded and stored files in their phones. It was also found that among teaching staff many were not aware of the capacity of their mobile phones such that they underutilized them. Costs associated with downloading multimedia content was another constraint which limited some respondents especially students from using phones for learning purposes. More than that, users were forced to use SMART/VISA cards for buying online mobile applications of which most respondents were not aware of (Mtega *et al*., 2012).

Sife *et al*., (2010)conducted a study to investigate the contribution of mobile phones to rural livelihoods and poverty alleviation in Tanzania and they found that mobile phones are useful in performing efficiently and effectiveness business, expand business and strengthening social networks as well as provide ability to handle emergency issues easily to citizens. Hassan and Semkwiji (2011) explored the role of mobile phones on sustainable livelihood in Arusha and Unguja (Zanzibar). They found that mobile phones are used as delivery tool for economic related information (e.g. business news), markets and market information (e.g. types and prices of different commodities), agricultural information (e.g. weather information, seeds varities), social information (e.g. ceremonies, deaths, and sickness), education information, Government and international information as well as religious information. Kadigi *et al*., (2013) investigated how information asymmetry between livestock keepers and other actors in local beef cattle can be address. They developed a system called 'e-ng'ombe' which till now is not yet fully implemented but if it could be implemented the problem of market information between different actors can be solved.

Similarly, Kihwele and Bali (2013) examined parents', teachers' and students' perceptions of the effects of students' access to mobile phones on students learning performance. They found that students' with mobile phone misbehave and hence have poor performance. Thus, they recommended the need to have a mobile control system for students who are using mobile phones. Also, they recommended the need to developing learning contents for students which will be censored to control the quality of mobile information. Furthermore, there is a need to having a mobile information literacy study for students. Chambo *et al.*, (2013) examined ten secondary schools in Kilimanjaro Region and they found that majority of students had mobile phones with Internet connectivity. Chambo *et al*. (2013) concluded that mobile learning platforms that were in place were not workable in all contexts.

From the literature reviewed in this study the major weakness of previous studies is that most of the studies were done without being guided by either theoretical framework or conceptual framework (Mtebe &Raisamo, 2014). Thus this study was guided by a combination theory and

conceptual framework (i.e. theoretical framework). Therefore, this study addressed the following questions: (i) what are the periods of conversations between undergraduate students and the people they talk to? (ii) how much money undergraduate students spent on mobile phones? and (iii) how is the mobile phone used by undergraduate students when they are in classrooms? The rationales for examining usage pattern of mobile phones among undergraduate students are many. The reasons for the importance of this study are as explained in this section. Authors believe that the study contributes in adding a work of literature. Also, the study will serve as a reference for telecommunications companies which need to investment their products in some universities in the country. In addition, this study fills the gap in knowledge in the areas of information science, communication and mobile informatics (Dahlbom & Ljungberg, 1998). Furthermore, the study can be used by systems analysts to design mobile learning (m-learning) appropriate for learning and teaching undergraduate students in the environments of low bandwidth. Finally, the findings from the study can be used by policy makers to develop appropriate policies for subsiding Internet to undergraduate students who will be using m-learning.

Theories Explaining the Use of Mobile Phones

The use of mobile phone for social and economic purpose is on the increase. Six theories contribute significantly in explaining the use and adoption of mobile phone among university undergraduate students. These include theory of technology acceptance; theory of reasoned action; theory of planned behavior; diffusion of innovations; domestication; and uses and gratifications (Venkatesh *et al*., 2003; Martin & Ajzen, 2010; Terry *et al*., 1993; Rogers, 2003; Pearce, 2013). Each of these theories is well explained below:

Theory of technology acceptance:

Theory of technology acceptance explains determinants of intentions to use or not to use a particular technology (Venkatesh *et al*., 2003). The key elements of intention construct identified in the theory are: perceived usefulness; perceived easy to use; attitude toward use; and intention to use and actual use. Further, the model explains factors that form basic constructs influencing mobile phone adoption, which include social influence expressed as the pressure exerted on the individuals by opinions of others; facilitative conditions or necessary infrastructure and perceived usefulness or the extent to which a user believes on the benefit accrued from using the mobile phone and perceived ease to use. According to the theory determining factors toward intentions for using mobile phone include personal factors such as preference and beliefs about the mobile phone. Yet others are demographic factors such as age, gender, education and social economic factors like occupation and income. These hold back or foster the intention of one to use the technology, i.e. a mobile phone. This theory is relevant in understanding the possible factors that do motivate or demotivate university undergraduate students to use mobile phones to communicate information.

Theory of reasoned action:

Theory of reasoned action stipulates that intentions to use a technology proceed from attitude toward that technology and toward its use, and the subjective norms (Martin & Ajzen, 2010; Terry *et al*., 1993). . This theory is important in understanding the influence of significant others

such as parents and close friends in communicating information using mobile phones. Significant others may be useful in various ways including buying mobile phones for university undergraduate students or friends, or even encouraging the use or ensuring the availability of money or airtime to them.

Theory of planned behavior:

The theory of planned behavior is the extension of the theory of reasoned action (Ajzen, 2012). On top of attitude and subjective norms as determinants of intension in the use technologies, i.e. mobile phone, this theory adds perceived control to the construct of intention. This is what is called self-efficacy in some other literature. It is the extent to which an individual feels that they require certain skills and knowledge to work with the technology and produce the required outcome. The theory of planed behavior is important in understanding the influence of technological training in using mobile phones to communicate information. Hence, the undergraduate students need to have various skills and knowledge including how to search for relevant information and they should be trained well in the technology i.e. mobile phone use for communication of information, Internet use, downloading documents, etc.

Diffusion of innovation:

Diffusion of innovation is the theory of how, why, and at what rate new ideas and technology spread through social systems (Rogers, 2003). Thus, diffusion of innovation can aid in the understanding or in exploration of complexities related to finding how undergraduate students use their mobile phones.

Domestication:

Another theoretical perspective that aligns well with mobile adoption and use is domestication (Haddon, 2003). This theory concentrates on how individuals go through the process of discovering, purchasing, and integrating devices into their lives, and helps to account for how individuals judge others', how they use the devices, as well as the social consequences of the device. Domestication can be a fruitful theory to use to undergraduate university students because it accounts for social uses and consequences.

Uses and gratifications:

The study of media choice of the mobile phone and other information communication technologies is sometimes examined from uses and gratifications perspective (Pearce, 2013). This approach is concerned with establishing the linkages between the kinds of motivations undergraduate university students might have for media.

Conceptual Framework

The variable that this study set out to investigate was the university undergraduate students' use of the mobile phone, which was the dependent variable of the study (Figure 1). The independent variables of the study were four: owning mobile phone and cost; money that university undergraduate students spent on mobile phones; university undergraduate students rating of mobile phone use; periods of the day that these students had conversations on their mobile

phones; and students' mobile phone use in classrooms. As in many empirical studies, the independent variables for this study were the specific objectives (Figure 1).

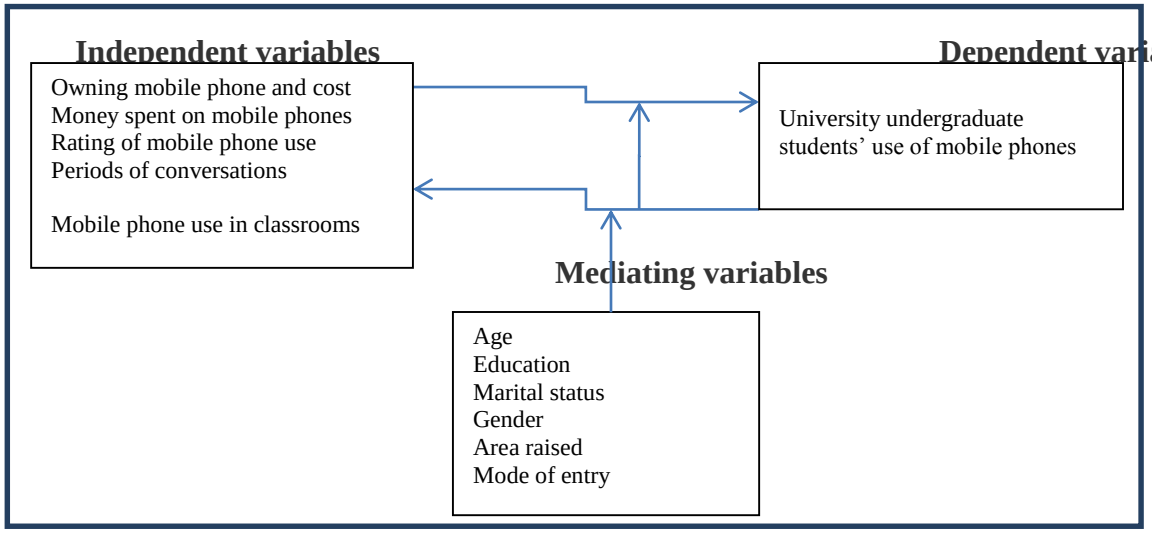


Figure1. Conceptual framework showing study variables for explaining university undergraduate students' use of mobile phones

Study Methodology

This study interviewed 302 university undergraduate students at Sokoine University of Agriculture (SUA) in Morogoro, Tanzania, East Africa. The broad objective of the study was to investigate university undergraduate students' use of mobile phones at Sokoine University of Agriculture. Specifically, the study examined the students' owning of mobile phones; assessed the money spent on the mobile phones; the students' rating of the mobile phones. Also, the study described the periods of the day, when conversations were held on mobile phones and people they talked to; and lastly the study described mobile phones use in classrooms.

SUA is located in Morogoro Municipality and has 3,350 hectares of land for training, research and production in Morogoro municipality. SUA has four faculties namely; the Faculty of Agriculture, Faculty of Forestry and Nature Conservation, Faculty of Veterinary Medicine and the Faculty of Science. The randomly sampled university undergraduate students came from two campuses namely, the main campus within Morogoro municipality; and Solomon Mahlangu Campus which is also in Morogoro municipality. In the 2012/2013 academic year 2,444 undergraduate students were enrolled, and in the 2013/14 it grew to 6,456 students. This study sampled randomly 302 undergraduate first year students in 2012/2013 academic year from 12 departments in the three faculties, of which 66.2% were males, and 33.8% were females.

The primary data were gathered using semi-structured questionnaires, which were validated using 20 randomly selected students and ten academic staffs at the University. Two pairs each consisting of ten undergraduate students were randomly selected and each asked to respond to

semi-structured questionnaires for reliability test. The results of the two groups were subjected to Cronbach alpha test, which yielded a 0.78, which was within the accepted reliability test of the study instruments. Other data were collected through key informants discussions, observation, transact walks, and the secondary data were gathered through review of documents and through the Internet and websites. The data collected using semi-structured questionnaires included respondents' socio-economic characteristics, owning of mobile phone and cost/ money that students spent on mobile phones, rating of mobile phone use and on periods when conversations were held on mobile phones. The collected data were checked, reduced, and entered in the Statistical Package for Social Sciences and later were analyzed to yield parameters such as percentages, means, etc.

Study Results

Respondents' socio-economic characteristics

This study interviewed 302 undergraduate students at Sokoine University of Agriculture and of these 200 (66.2%) were males and 102 (33.8%) were females. Most, 229 (75.8%) were in the age range of 20-26 years old, while 40 (13.2%) were 27-32 years old. Of the 302 respondents, most, 251 (83.1%) indicated that they were single, and only 47 (15.6%) were married. Half of the respondents, 151 (50.0%) reported that they were raised in rural areas, while 141 (46.7%) said in urban areas. Over two thirds, 185 (61.3%) of the respondents indicated that they had completed Form IV in 2008, and 183 (60.6%) mentioned that they had completed Form VI in 2011. Of all the respondents, most, 227 (75.2%) reported that they were pre-service students, and few 58 (19.2%) were in-service students.

Owning Mobile Phone and Costs

Of the 302 respondents, less than half, 126 (41.7%) agreed that they bought mobile phones themselves. Further, of all the respondents, 147 (47.0%) mentioned that they started owning mobile phones from 2003 to 2007, while 123 (40.7%) indicated to have started owning mobile phones from 2007 to 2011. The range of cost that respondents paid for their mobile phones varied greatly. Of all the respondents, few, 57 (18.9%) and 52 (17.2%) indicated that their mobile phones were priced at the range of Tanzanian shillings (Tshs) 10,000 to 40,000 (US$ 6.20 to 24.80) and Tshs. 40,001 to 70,000 (US$ 24.80 to 43.48), respectively. (Exchange rate used was 1 US$ equivalent to Tshs. 1610 on 11th March 2014). Further, few, nine (3.0%) and five (1.7%) reported that the cost was in the range of Tshs. 70,001 to 100,000 (US$ 43.48 to 62.10) and 100,001 to 130,000 (US$ 62.10 to 80.75), respectively. Few, three (1.0%) mentioned that their phones were priced above Tshs. 130,001 (US$62.10).

Similarly, of all the respondents, 65 (21.5%), 29 (9.6%) and 16 (5.3%) reported that fathers, mothers and brothers gave them the mobile phones they owned. Yet, 14 (4.6%) and ten (3.3%) indicated that parents and sisters gave them the mobile phones they owned, respectively. Others mentioned sources of mobile phones were from uncles--(2.3%), aunts and husbands-- (each 1.7%). Most of the respondents, 225 (74.5%) reported to have owned mobile phones for the past five years, while few, 33 (10.9%), 23 (7.6%) and 12 (4.0%) had owned phones for four, three, and two years, respectively.

Of all the respondents, a third, 104 (34.4%) reported that others influenced them to buy mobile phones. Yet few, 45 (14.9%), 44 (14.6%) and 30 (9.9%) mentioned that their fathers, mothers and brothers, influenced them to buy mobile phones, respectively. Other people mentioned to have influenced respondents to buy mobile phones were: boyfriends—23 (7.6%), girlfriend—19 (6.3%), and sisters—14 (4.6%). Of all the respondents, 71 (27.2%) mentioned that communicating family-related information was the most perceived reason to buy mobile phones. Other perceived reasons mentioned for buying mobile phones were reported as: to keep in touch with friends—71 (23.5%), to communicate business-related information—57 (18.9%), to communicate emergency--related information—19 (6.3%), and other information—23 (7.6%).

Again, of the 302 respondents, over two thirds, 209 (69.2%) agreed that their phones had Internet services, and 193 (63.9%) agreed that they used the Internets to search for information in their field of specialization. However, few, 119 (39.4%) of the respondents agreed that they used their mobile phones to search for information in their area of specialization generated in the country. Yet, few, 114 (37.7%) of the respondents agreed that they used their mobile phones to search for information in their area of specialization generated at Sokoine University of Agriculture, but about over two thirds, 185 (61.3%) agreed that they used their mobile phones to search for knowledge in their area of specialization generated from elsewhere. Also, few, 97 (32.8%) of the respondents agreed that they used their mobile phones to search for information in their area of specialization generated from outside the country.

Money spent on mobile phones

Within the 302 involved respondents, about half, 148 (49.0%) indicated that they spent less than Tshs. 1,000 (US $) per day to recharge their mobile phones. Yet a quarter, 78 (25.8%) of them said that they used in the range of Tshs. 1,000 (US$0.62) to 2,000 (US$ 1.24) per day to recharge their mobile phones. This is to say, most, 226 (74.8%) of the respondents mentioned that they spent less than Tshs. 1,000 (US$ 0.62) to Tshs. 2,000 (US$ 1.24) amount of money per day to recharge their mobile phones. Also, the study findings show that, 37 (12.3%) and 22 (7.3%) of the respondents mentioned that they spent Tshs. 500 (US$ 0.31) and Tshs. 1,000 (US$ 0.62) per day to recharge their mobile phones. Again, most, 226 (74.8%) of the respondents mentioned that they spent less than Tshs. 1,000 (US$ 0.62) to Tshs. 2,000 (US$ 1.24) per day to recharge their mobile phones. Further, over two thirds of the respondents, 186 (71.6%) mentioned that they spent in the range of Tshs. 1,000 (US$ 0.62) to Tshs. 3,000 (US$ 1.86) in three days to recharge their mobile phones, while few, 29 (9.9%), 22 (7.3%) and 19 (6.3%) said in the range of Tshs. 1,500 (US$0.93), less than Tshs. 1,000 (US$ 0.62), and Tshs. 3,000 (US$ 1.86), respectively. Additionally, over half, 157 (51.1%) of the respondents reported that they spent in the range of Tshs. 3,000 (US$ 1.86) to Tshs. 5,000 (US$ 3.10) in seven days (per week) to recharge their mobile phones.

Table 1: Money that undergraduate students at SUA received and spent on mobile phones in 2012/1 and 2013/14

Year	2012/2013			2013/2014		
# of students	2,444*			6,456*		
Students' allowances	11,738,396,080**			12,714,394,000**		
Voucher price	500	1,000	1,500	500	1,000	1,500
Tshs/day spent	1,222,000	2,444,000	3,666,000	3,228,000	6,456,000	9,684,000
Tshs/week spent	8,554,000	17,108,000	25,662,000	22,596,000	45,192,000	67,788,000
Tshs/month spent	36,660,000	73,320,000	109,980,000	96,840,000	19,680,000	290,520,000
Tshs/year spent	446,030,000	892,060,000	1,338,090,000	1,178,220,000	2,356,440,000	3,534,660,000
Tshs/stud./yr spent	185,500	365,000	547,500	185,500	365,000	547,500
% average spent	5.2	7.6	19.1	9.3	18.5	27.8

*Figures were obtained from SUA Student Records Office in 4th March 2014; **Figures sourced from SUA Accounts Department, 5th March 2014.

The data in Table 1 show that of the 2,444 students enrolled in 2012/13 academic year received allowances from the Tanzania Higher Education Students' Loans Board (THESLB) totaling Tshs. 7,267,899,550 (US$ 4,514,223.30). Of this money, they spent an average of 8.1% of their allowance money to buy vouchers to charge their mobile phones. Also, in 2013/2014 academic year the University enrolled 6,456 students who received allowances from the THESLB totaling Tshs. 12,714,394,000 (US$ 7,897139.31)spent an average of 18.5% of their allowance money to buy air time vouchers to recharge their mobile phones. The data show that as students' enrollment at the University increased the money spent in mobile phones also increased. Implications of these findings are that there is sizeable amount of money that students at the University spend in mobile phones (Table1). Generally, due to this, mobile companies appear to make huge amounts of money countrywide from university students.

Of all the respondents, 109 (36.1%) reported that during the working days (Monday to Friday) they mostly talked to their mothers, and next others were: girlfriends—38 (12.6%), boyfriends—25(8.3%), fathers—18(6.0), sisters—10 (3.3%), and others 85 (28.1%). Of the 302 respondents, 0ver a third, 124 (41.1%) and 115 (37.5%) mentioned that family-and social-related messages were mostly communicated in the working days, respectively. Yet few, 24 (7.9%) and ten (3.3%) mentioned that they communicated school- and business-related messages, respectively. Of all 302 respondents, majority, 147 (48.7%) reported that they had multiple frequencies of texting SMS on their mobile phones per day while few, 33 (10.9%), 26 (8.6%), and 13 (4.3%) mentioned that the frequencies of texting SMS on their mobile phones were once a day, one to five times per day, and once in a week, respectively.

Rating of mobile phone use

Further, of all respondents, about two thirds, 190 (62.9%) rated the use of mobile phones for family calls as the most important aspect, while 38 (12.6%), and 21 (7.0%) rated it as important and about average, respectively. Yet, about a third, 108 (35.8%) of the respondents mentioned that the use of mobile phones for receiving calls was rated as the most important, while 36 (11.9%), 18 (6.0%) and 13 (7.0%) rated it as about average, least important, and somehow important, respectively. Also, 89 (29.5%) and 61 (20.2%) of the respondents indicated that the use of mobile phones for composing and sending SMS was rated as the most important and important, respectively. On the same vein, few 45 (14.9%), 34 (11.3%), and 29 (9.6%) rated mobile phones as somehow important, about average, and least important, respectively. Additionally, few, 89 (29.5%) and 61 (20.2%) of the respondents mentioned that the use of mobile phones for composing and sending out SMS was rated as the most important and important, while 45 (14.9%), 34 (11.3%), and 29 (9.6%) rated phones as somehow important, about average, and least important, respectively. On other hand, majority of the respondents rated the use of mobile phones for playing games as least important, reported by 183 (60.6%), while internet use on phones was rated as the most important, by only 80 (26.5%). Yet, other ratings for internet use on phones were: 63 (20.9%) least important; 53 (17.5%) important; 37 (12.3%) about average; and 17 (5.6%) least important.

Moreover, less than half of the respondents, 131 (43.4%) reported that the use of mobile phones for calling university mates to discuss university take-home assignments was rated as the most important, while 72 (23.8%), 34 (11.3%), 16 (5.3%) and 11 (3.6%) of respondents rated it as important, about average, somehow important, and least important, respectively. Of all the respondents, few 80 (26.5%) and 56 (18.5%) mentioned that the use of mobile phones for keeping themselves updated with university almanac. This was rated as the most important and least important, respectively. On the same vein, 49 (16.2%), 43 (14.2%), and 25 (8.3%) rated phones as somehow important, important, and about average, respectively. Similarly, of all the respondents, few 83 (27.5%), 67, and 49 (16.2%) reported that the use of mobile phones for making and keeping university instructors' appointments were rated as most important, least important, and important, respectively. In addition, few 28 (9.3%) and 25 (8.3%) said that the use of mobile phones for making and keeping university instructors' appointments were rated as about average and somehow important, respectively.

Periods of conversations and the people they talked to

Further, of all the respondents, 86 (28.5%) reported that during the non-working days (i.e. Saturday and Sunday) they mostly talked to their mothers, and next others were: girlfriends—35 (11.6%), fathers—27 (8.9%), boyfriends—25(8.3%), brother 24 (7.9%), sisters—8 (2.6%), and others 78 (25.81%). Specific time that respondents had conversations on their mobile phones on non-working days differed greatly. For instance, 69 (22.8%), 65 (21.5%), and 63 (20.9%) reported that they made conversations on their mobile phones in the evenings (6 pm to 8 pm), at nights (8 pm to 12 pm), and in the afternoons (2 pm to 5 pm), respectively. Yet few, 53 (17.5%) and 17 (5.6%) indicated that they made conversations on their mobile phones in the mornings (6 am to 12 am) and in the afternoons (12 pm to 2 pm), respectively. Of the 302 respondents, over a third, 119 (39.4%) and 110 (36.4%) mentioned that social-and family-related messages were

mostly communicated in the non-working days, respectively.

Also, on working days, that is, Monday to Friday, time when they made conversations on their mobile phones to various people differed widely. Of all the respondents, one third, 102 (33.8%) of respondents who were the most, reported that they had conversations on their mobile phones at night (from 8 p.m. to 12 pm), while few, 83 (27.5%) and 58 (19.2%) reported to have conversations on their mobile phones in the evenings (6 pm to 8 pm) and in the mornings (6 am to 8 am), respectively. The other period mentioned was in the afternoons –39 (13.0%) (2 pm to 4pm). Over two thirds of the respondents, 220 (72.8%) mentioned that they preferred to have conversations on their mobile phones in the evenings and at night because it was the free time available to them.

Mobile phones use in classrooms

Most respondents, 238 (78.8%) disagreed that they received phone calls on their mobile phone when they were in the classrooms, while few, 55 (182) agreed to the statement. Further, over half, 173 (57.3%) of the respondents agreed that students' learning was affected by receiving mobile calls when attending classes. Also, many respondents, 226 (74.8%) indicated that they kept their mobile phones in the mute mode when attending classes, while few, 20 (6.6%) said so when taking tests and examinations. Further, few 108 (35.8%) mentioned of putting their mobile phones in vibration mode when attending classes, while others said when: sleeping – 27 (8.9%), doing class assignment – 26 (8.6%), in library, office, and discussion groups – each 19 (6.3%). However, few respondents reported switching off their mobile phones when: in examination rooms – 82 (27.2%), in classes – 61 (20.2%), taking tests – 45 (14.9%), sleeping – 14 (4.6%), and with supervisors – 10 (3.3%).Over two thirds of the respondents, 198 (65.6%) agreed that they got annoyed with instructors who received calls on their mobile phones when teaching. Similarly, majority of the respondents, 221 (73.2%) agreed that they got annoyed with instructors who made calls out on their mobile phones when teaching. Of all the respondents, most, 247 (81.8%) agreed that SUA should have bylaws that control and regulate students' and instructors' mobile phone usage in classes and examination rooms.

Discussions

Periods of conversations and the people students talked to

Further, of all the respondents, 86 (28.5%) reported that during the non-working days (i.e. Saturday and Sunday) they mostly talked to their mothers. Of the 302 respondents, over a third, 119 (39.4%) and 110 (36.4%) mentioned that social-and family-related messages were mostly communicated in the non-working days, respectively. On working days, that is, Monday to Friday, of all the respondents, one third, 102 (33.8%) who were the most reported that they had conversation on their mobile phones at night (from 8 p.m. to 12 pm), because it was the free time available to them said by 78.2 percent.

A study at Virginia Tech, Blacksburg, Va., USA studied 568 undergraduate students had mobile phones and found that 80% of the cell phone users talk between 6pm and midnight, and the three main categories of cell phone calls were family members, boyfriends or girlfriends, and

friends/relatives. Further, the study found that female students differed from male students by using their cell phones for communication with immediate family members, including parents, speaking more often, and talking for longer times (Belew, 2007)

A total of 500 undergraduate students from East Tennessee State University, USA were examined on their text messaging behavior. The findings revealed that age is the strongest predictor of text messaging; with younger respondents being more likely to text. The study also shows that women prefer texting, while men prefer voice calls. Age affects preference as well, with younger respondents preferring texting and older respondents preferring voice calls. The study also found that women are much more likely to use cell phones to avoid others during co-present interaction. Around 60 percent (289) said they texted their friends very frequently compared to other categories. Twenty-six percent of respondents (118) very frequently texted "others," while 15.1 percent (69) texted siblings very frequently. Approximately eight percent (37) and five percent (15) texted their parents or child very frequently, and around 34 percent of respondents (164) stated they called their friends frequently or very frequently. By contrast, nearly 70 percent of respondents (339) frequently or very frequently called their parents. Parents were thus the most likely category to receive voice calls from participants (LaBowe, 2011).
In the Tanzanian context, these findings led us to question whether or not a student's overall frequency of cellular phone use at night impacted on their overall academic performance. This could be a question in other future studies.

Money spent on mobile phones

This study has established that most students spend Tshs. 1,000 (US$ 0.62) per day to buy airtime to recharge their mobile phones, and of the 2012/2013 academic year the 2,444 enrolled students spent Tshs. 2,444,000 (US$ 1,518.00) per day, which implied a 7.6% expenditure of their allowances per year. Extending further, we used university students' enrollment data for 2010/2011 academic year as provided by the Tanzania Commission for Universities (TCU) for Tanzania to calculate the national students' expenditure of their allowances in mobile phones. In all universities (11 public and private), students' data of enrollment for 2010/2011 academic year was 135,367, of which 88,178 (65.1%) were males and 47,189 (34.95) were females (TCU, 2012).Therefore, countrywide, all undergraduate students in these universities spent Tshs. 135,367,000 (US$ 84,078.90) per day or Tshs. 49,408,955,000 (US$ 30,688,791.90) per year. This is a huge sum of money to be spent on non-material activity of recharging mobile phones, especially in a poor country like Tanzania. To extend the discourse is the frugal expenditure of the tax payers' money that students get from the THESLB as loans and partly use it on mobile phones. Worse still is that these loans are partially repaid back to the government by the students after graduating. Most of them after graduation become unemployed or are employed in sectors that are difficult to trace, and/or change jobs many times that they cannot be easily traced on their whereabouts.

This phenomenon is not unique to Tanzania as other findings from elsewhere are indicative. A survey polled 900 Kenyan youth aged between 16 and 24 and found that they are constantly on their cellular phones – texting and surfing the Internet – and sending an average of 250 messages as texts and chat posts daily. They spend the biggest portion of their income on mobile phone (about KShs.900 monthly) airtime (79%) and trendy clothing (78%) (Herbling, 2012). In UK for

instance, Save the Student estimates that the typical student spends £24 a month on their mobile phone, plus another £12 a month on the internet and home phone connections (Mohammed & Collinnson, 2012). Zulkefly and Baharudin (2009) study of N=386 students at the University of Putra, Malaysia, found that students spend on average 6 hours daily and USD18.70 monthly on their mobiles. In their study, the text message was the most used feature and peers were the most frequently contacted people. Further, in Australia, Zulkefly and Baharudin (2009) quoting the Australian Psychological Society (2004) reported that a study revealed that a large proportion (66%) of Australian adolescents preferred to use the mobile phone pre-paid system. This system allowed adolescents and their parents to monitor and control the mobile phone cost of their children. In summary, the reviewed studies show that it is true that worldwide students in universities spend substantial amounts of money on their mobile phones, and therefore, policies must be put in place to curb such frugality, especially in the state-funded university education like SUA.

Mobile phones use in classrooms

Most respondents, 238 (78.8%) disagreed that they received phone calls on their mobile phone when they were in the classrooms, while few, 55 (182) agreed to the statement.Further, over half, 173 (57.3%) of the respondents agreed that students' learning was affected by receiving mobile calls when attending classes. Also, many respondents, 226 (74.8%) indicated that they kept their mobile phones in the mute mode when attending classes.

Studies from other countries show that indeed this is a common problem. For example, a study at University of New Hampshire, Whittemore School of Business and Economics interviewed 1,265 students. Almost all (99 percent) of the college students owned cellular phones. And half of them (51 percent) said that cell phone use in class affects their ability to concentrate and the amount of information that they receive during class (52 percent). The most commonly used phone feature was the clock, followed by texting. The study found that, although students were aware that phone use was frowned upon in class, almost half (49 percent) of those who checked their phones during class attempted to conceal their use somewhat or extremely frequently. The study found also that female students were found to be 7 percent more likely to text, or more times per class period, and they were also 13 percent more likely to frequently hide their phone use in class. Female students were 5 percent more likely to text frequently during class (Alfano *et al*., 2010).

The other study was conducted by McCoy (2013) which involved 777 students from six U.S universities in 2012. The results showed that on average, respondents used a digital device for non-class purposes 10.93 times during a typical school day for activities including texting, social networking, and emailing. Digital Distractions in the Classroom: Student Classroom Use of Digital Devices for Non-Class Related Purposes. The study found that most respondents did so to fight boredom, entertain themselves, and stay connected to the outside world. More than 80% of the respondents indicated such behavior caused them to pay less attention in the classroom and miss instruction. Majority of respondents favored policies governing digital device distractions in the classroom. Other reviewed studies which seem to have similar findings are those of Zulkefly and Baharudin (2009) in Malaysia, Economides and Groupoulou (2008) in Greek, in the Pearson Student Mobile Device Survey 2013 National Report in the U.S.A and

Europe as reported by Abeele and Roe (2011) and also by Leung (2001). These findings led us to question whether or not a student's overall frequency of cellular phone use has impacts on his/her overall academic performance, as measured by a student's grade point average (GPA). This can be an area for future research.

Conclusion, limitation of the study and Future research

This study examined the pattern of the use of mobile phones among university undergraduate students at Sokoine University of Agriculture. The study reports on the following questions: (i) what are the periods of conversations and the people students talk to? (ii) how much money is spent on mobile phones? and (iii) how is the mobile phone used in classrooms? The study found that most students use their mobile phones for social aspects. This is mostly done during late hours after having attended classroom. Also, the study found that the money spent for mobile phones is very huge compared to the money they spent in buying books. Finally, the study found that the use of mobile phones for learning purposes (i.e. mobile learning or m-learning) is not yet fully implemented in most Higher Education Institutions in Tanzania (Bhalalusesa & Arshad, 2014; Mtebe, 2016).

The use of a convenience sample was a major limitation of this study. Consequently, it was not possible to generalize the findings to the general population. Moreover, respondents sometimes could provide untruthful answers to survey questions. The respondents may do this because they feel embarrassed or for other personal reasons. As a result, some information in this study may reflect this lack of truthfulness. The study would have been more complete, if focus groups had been used in conjunction with questionnaires. Focus groups provide researchers the opportunity to gain a more in-depth knowledge about subjects than questionnaires alone. Breaking up groups into various ages and dividing them by sex would have greatly enhanced the results of this study. Hence, the study would have benefited by using student focus groups. Each of these deficiencies can be easily corrected by future researchers. Nevertheless, even with these limitations, the current study adds to the body of literature on cellular phone behavior and provides valuable direction for future research in m-learning.

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TANZANIA NATIONAL FIBRE BROADBAND BACKBONE: Challenges and Opportunities

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ABSTRACT

The study on operational efficiency brought by the National ICT Broadband Backbone (NICTBB) to service providers was conducted in mobile communication companies in Tanzania. The study wanted to identify the status of fibre infrastructure in Tanzania and East Africa, to examine factors which cause low utilization of the Tanzania National ICT Broadband Backbone (NICTBB) and to determine strategies to improve the applicability of the National ICT Broadband Backbone. This paper presents the results from that study.

Using case study, the study found out of 90 respondents 40, (44.4%) identified the coverage of the fibre infrastructure is satisfactory. The study concluded that the status of the NICTBB satisfactory in terms of coverage since it covers major parts of the country. It is also concluded that NICTBB meet capacity requirements. Moreover, the study concluded that price is a major reason for underutilization of the fibre infrastructure, other factors involves; lack of awareness, slow internet growth, lack of local contents and unfavourable government policies. The study recommended that there is a need of increase awareness to public to foster full utilization of the NICTBB. The connectivity prices should also be regulated and affordable to huge number of users, special rate to Government institutions and research centres.

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The study brings more insight to policy makers to come up with proper mechanisms on challenges impeding telecommunication companies in ICT operations. It would also inform the ongoing policy debates on the effectiveness of National ICT Broadband Backbone for Tanzania economy. IT will also be useful to all stakeholders in the industry including ISP, scholars and investors.

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INTRODUCTION

1.1 National information and Communication Technology Broadband Backbone (NICTBB) Project

The Government of Tanzania through its project embarked on the National information and Communication Technology Broadband Backbone (NICTBB) Project [Lange, 2009; Mfungahema, 2006]. The NICTBB roll out began in 2009 aimed at installation of the National fibre optic broadband backbone connectivity which will enable to get fast, reliable and affordable the internet connections. In line with the National ICT Policy [2003], currently under review, Tanzania has already built a high capacity state-of-art NICTBB that offers high quality services at utility prices, having reduced the backhaul tariffs by 99% compared to 2009 tariffs [Koutroumpis, 2009]

Phase I and II of the project which was completed since 2012 created 7560km backbone that has point of presence (PoPs) at all regional headquarters [NICTBB, 2016]. By design the NICTBB addresses national needs and those of the landlocked neighbouring countries by offering both cross-border connectivity and access to four International submarine cables: SEACOM, EASSY, SEAs and TEAMS (at Mombasa, Kenya). This broadband readiness, supplying abundant national and international bandwidth, is fast enabling eMarkets in Tanzania to emerge and are growing, leveraging the growing popularity of

eTransactions already backed by Mobile electronic money transfer services. These eTransactions will continue to permeate people's life styles extending to eLearning, eHealth and eGovernment [Wellenius, 2003].

Phase III aims at enhancing the infrastructure to reach the all the district headquarters in order to facilitate the provision of services such as data centres as well as supporting public organization, research and academic institutions [NICTBB 2016].

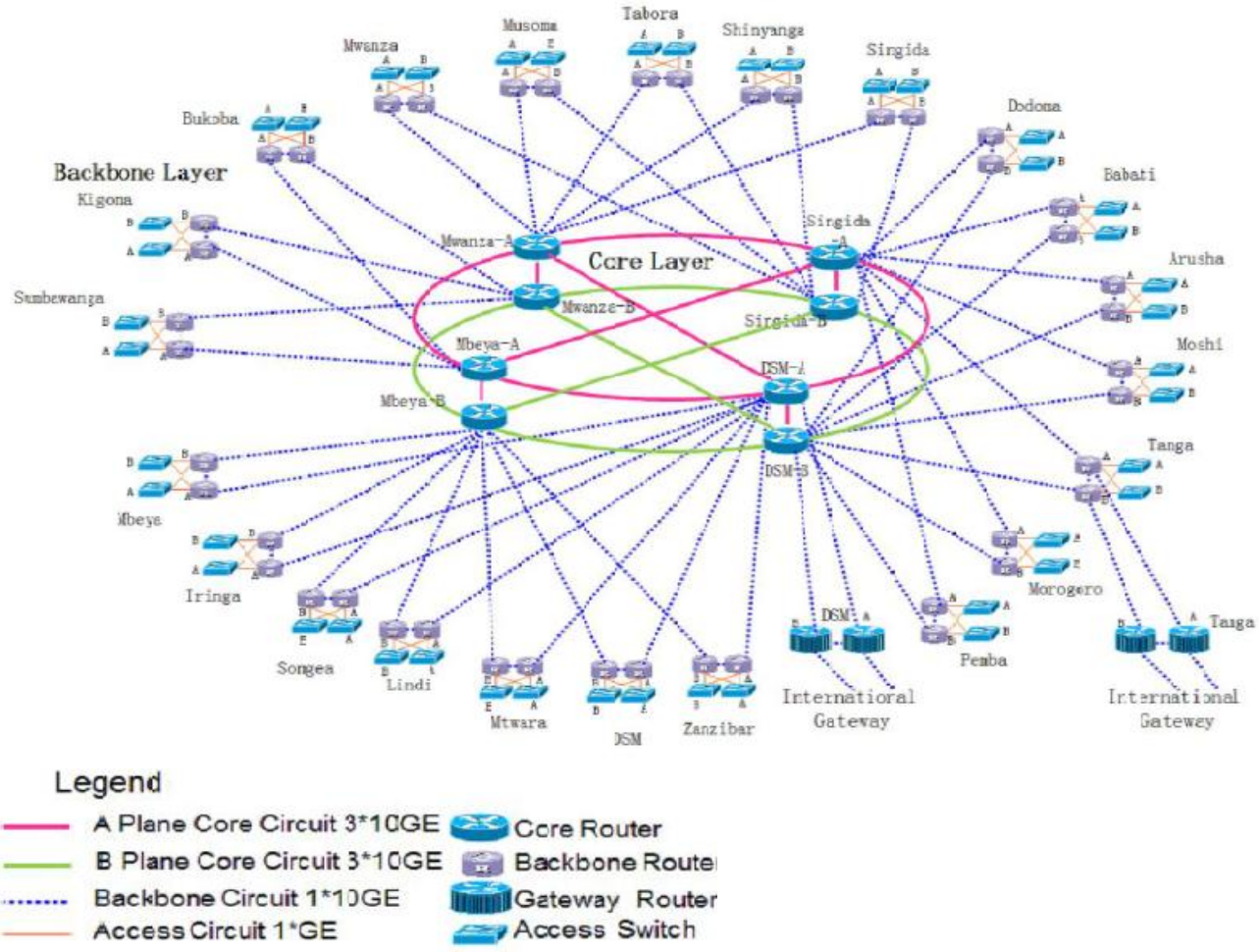


Figure 1: The NICTBB Architecture of the IP Backbone Network [NICTBB 2016]

Phase IV will engage private sector especially telecom operators to roll out Metro Rings Networks in urban areas while Phase V will focus on implementing last mile broadband connectivity national wide to link institutions and most importantly, general public

[NICTBB 2016]

Moreover, NICTBB has the potential to accelerate ICT adoption and can be sustained to create a higher socio-economic impact through aggressive content development that will be delivered using the available broadband connectivity as it is extended to cover communities, schools, higher learning and research institutions, hospitals and associated health facilities, government offices, and businesses [Lange, 2009]. Prospectively, the broadband connectivity opportunity is a multibillion-dollar eMarket for content and other e-services [TCRA, 2006].

The introduction of Backbone networks in Tanzania has a major impact on the commercial viability of ICT services, particularly broadband. In a typical mobile phone network, the backbone network accounts for 10–15 percent of total network costs [Smith *et al*, 2006]. The cost of backbone networks is much higher for operators providing broadband connectivity, particularly in small towns and rural areas. If an area does not have a backbone network offering low-cost network services, broadband connectivity is unlikely to be commercially viable [TCRA, 2012].

1.2 The Challenge

The NICTBB set up began in 2009, the overall objective was the installation of the National fibre optic broadband backbone connectivity which will enable to get fast, reliable and affordable the internet connections. This would boost the nation's internet connectivity/coverage rate [Stephen 2008]. The Government of Tanzania spent over 250 billion in investment of this National fibre optic [TCRA, 2012]. Notwithstanding of the effort done by the government of Tanzania still the NICTBB is not being fully utilized to its full potential. By 2010, the backbone was operating at less than 10% of its installed capacity and even lower at its design capacity [Lange, 2010]. This was also because there was only phase one and two completed, connecting regional headquarters.

There is a need for full utilization of the NICTBB, full utilization of the NICTBB will; reduction in transport, travel and distribution costs. Furthermore ICTs applications enable

efficient communication online, where information and reports can be shared amongst members without physical gathering, meetings can be held remotely, and some assignments can be carried out from homes or without necessarily travelling all the way from homes to the work places or in another country, particularly in cities where traffic jams are order of the day [Lange, 2009]. Generally, the study presented in this paper intended to assess operational efficiency brought by the National ICT Broadband Backbone [NICTBB] to service providers. Starting with identifying the status of fibre infrastructure in Tanzania and East Africa, the study also wanted to examine factors which cause low utilization of the National ICT Broadband Backbone [NICTBB] and finally to determine strategies to improve the applicability of the National ICT Broadband Backbone.

LITERATURE REVIEW

2.1 Status of ICT in Tanzania

Tanzania has made remarkable progress in deploying ICT which has been well received by the citizens and service providers who are striving to address unmet demand and competition in newly liberalized markets [TCRA, 2012; Mfungahema, 2006]. Tanzania's tele-density is low, with the number of fixed and mobile cellular lines currently standing at 12 telephone lines per 1000 people (a teledensity) and the number of mobile phone subscribers currently stands at 81 per 10,000 inhabitants. Tanzania's Public Switched Telephone Network (PSTN), using fibre optic, microwave and satellite-based links, is now over 95% digital. This paves the way for allowing the provision of new services enabled by ICT (August, 2012). The coverage of the network infrastructure is limited to urban areas and thus lack of telecommunications and other infrastructures in the rural areas remains a basic impediment to the provision of such new ICT services [Hughes and Lonie, 2007].

By 2005, as observed by Mfungahema [2006], the Tanzania Communications Commission [TCC], now TCRA had licensed nine companies to provide public data communication services including Internet bandwidth. These data operators had isolated

initiatives of connecting their Points-of-Presence (PoPs) to the global Internet backbone. As a result, Tanzania lacked cheaper and high capacity connections to the global Internet. All connections, regardless of the data service provider, are small capacity international links that connect to the global Internet backbone in different countries such as Norway and the United States. Therefore, the limited international Internet bandwidth was scarce and extremely expensive. The lack of a national Internet Exchange Point [IXP] also meant that much of Tanzania's local traffic was routed via international routes [Mfungahema, 2006].

Availability of personal computers is still very low in Tanzania: less than 1%. Multipurpose Community Telecentres (MCTs), offering basic telecom services like telephone, fax, Internet, e-mail and computer facilities designed to serve both individuals and businesses, and to provide training and distance learning services, are few and far between [Holcomb and Hitt, 2007]. However, most Tanzania have adopted quickly to the use of cellular phones, in which over 38 million phones are registered [TCRA 2016].

Tanzania's first MCT was established in 2000 by the Tanzanian Commission for Science and Technology [COSTECH] in partnership with the Canadian International Development Research Centre, UNESCO, the Danish International Development Agency and TTCL. Evaluation of these centres may reveal important information about the best way to expand the service. In the period under review, Vodacom established Internet cafes in three towns: Dar es Salaam, Dodoma and Arusha, using its 3G mobile network under the 'Wireless Reach' initiative. In collaboration with the GSMA Development Fund and Qualcomm, the initiative encourages the cafes to be run by local entrepreneurs [Stephen, 2008, Sedoyeka, 2015].

2.2 Internet Coverage

Tanzania's Internet sector had remained underdeveloped due to the limited reach of the traditional fixed-line network and the lack of international fibre connections [Koutroumpis, 2009]. Until the arrival of the first international submarine fibre cable in July 2009, the country relied entirely on satellite links for its international Internet bandwidth, which resulted in high retail prices that were unaffordable to the majority of the population. Internet cafes have contributed to some degree of Internet usage, but in terms of Internet penetration Tanzania still lags behind other countries in the region with similar GDP per capita and literacy levels [TCRA, 2010]. Mobile network operators are well positioned to become key players in Internet service provision with their extensive national infrastructure, following the introduction of mobile data and 3G broadband services [Lankford and Parsa, 2009].

The Internet market in Tanzania is likely to be driven by businesses that can use a combination of Internet and mobile telephone technology to offer enhanced but affordable services. Potential areas include payment of utility bills, accessing news, radio, mobile banking, election campaigns, and education. The landing of the Seacom submarine cable in Dar es Salaam has already impacted on cost. Effective October 2009, the TTCL reduced its Internet prices by more than 50% [Mfungahema, 2006]. According to the TTCL, high volume Internet users like banks, large businesses and corporations, government agencies and educational institutions were expected to be the main direct beneficiaries thus far. However, with the availability of cost effective internet services from mobile companies and the increase use of smart devices such as smart phones, the number of citizens with access to information has increased significantly with over 34% (of the population) internet penetration [TCRA 2016].

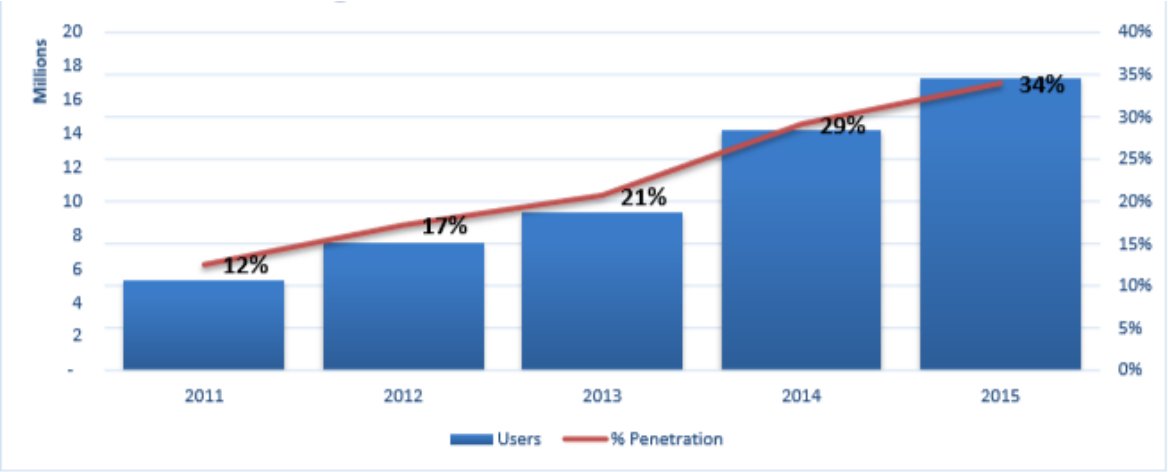


Figure 2: Trend of Internet Penetration [TCRA, 2016].

Tanzania like most of the developing world has witnessed a significant rise on the number of Internet users [ITU, 2014]. In 2009, Tanzania received $100millon in credit through the World Bank International Development Association under the Regional Communications Infrastructure Programme (RCIP3) to promote affordable communications services in the country [Yonazi, 2012]. The RCIP3 grant is planned to enable Tanzania to leverage developments in the telecommunications sector and overcome associated challenges through a combination of sound policy and regulatory frameworks, competitive market structures, and catalytic investments into public-private partnerships to accelerate the rollout of infrastructure networks that are aimed at enhancing universal access [Yonazi, 2012]. Building the national backbone and the establishment of the Universal access fund are such developments. Despite considerable developments in the ICT sector, Tanzania has only 1.3 percent telephone and Internet user penetration as compared to 6.7 for Africa [Holcomb and Hitt, 2007].

In November 2009, Convergence Wireless Networks (Convergence Wireless), a joint venture between Convergence Partners and Comsol Wireless Solutions (Comsol), acquired a 35% stake in the WIA Company Limited (WIA), a Tanzanian wireless connectivity provider focused on the enterprise market segment (Lange, 2010). Convergence Wireless aimed to providing high-level support at strategic and operational

levels and facilitate access to resources across the wider convergence partners' network. As observed by Stephen, [2008], WIA's growth strategy focuses on upgrading its core network around Dar es Salaam, deployment of a new national WiMAX access network covering key business centers, as well as the broadening of its value-added solutions to include virtual private networks, managed network services and applications hosting for large enterprises across the country. So far, traditional cellular companies have turned up to be the champions for internet penetration in Tanzania as users have turned into mobile devices to access the Internet [Gupta et.al., 2013, Meeker and Wu, 2013].

2.3 The National Fiber Backbone

The national fibre backbone, which is owned by the government under the operational management of the TTCL [NICTBB], aimed at installation of the National fibre optic broadband backbone connectivity which will enable to get fast, reliable and affordable the internet connections. According to TCRA, [2010], the national fibre optic broadband, which began rollout in 2009, enables cheap and efficient internet connectivity. The backbone has networked all regional headquarters within the country and connect Tanzania with its eight neighbours: Kenya, Uganda, Rwanda, Burundi, Democratic Republic of Congo, Zambia, Malawi, and Mozambique. Investment in 3G network development is evident, especially from the main mobile phone operators, Vodacom, Zain, Tigo, the TTCL and Zantel. In 2009, Zain Tanzania Ltd. secured US$270m from a mix of local and international lenders to support its continuing network expansion. In total, by the end of 2009, Zain had invested over US$500m in network infrastructure development [Lange, 2009].

Vodacom secured a syndicated loan of US$90m to finance its company capital expenditure. A dormant project, initiated with support from the Ericsson Group and UNEP, to establish bio-fuel powered radio base stations in two regions in Tanzania was activated in 2009. Undertaking the feasibility, Diligent Energy Systems BV noted that if Ericsson would get the backing of one or two major mobile phone operators, the project would be commercially viable. The project aims at bringing reliable but environmentally safe mobile phone services to rural people in Mtwara and Lindi. There is concern about

the operational safety of the increasing number of base stations, antennas and other facilities that support mobile phone transmission [Koutroumpis, 2009].

The Internet backbone is a conglomeration of multiple, redundant networks owned by numerous companies. It is typically a fibre optic trunk line. The trunk line consists of many fibre optic cables bundled together to increase the capacity. The backbone is able to reroute traffic in case of a failure. The data speeds of backbone lines have changed with the times. In 1998, all of the United States backbone networks had utilized the slowest data rate of 45 Mbit/s. However the changing technologies allowed for 41 percent of backbones to have data rates of 2,488 Mbit/s or faster by the mid 2000's [Helpman, 2012]. The economic geography of the Internet's infrastructure. Fibre-optic cables are the medium of choice for Internet backbone providers for many reasons. Fibre-optics allows for fast data speeds and large bandwidth; they suffer relatively little attenuation, allowing them to cover long distances with few repeaters; they are also immune to crosstalk and other forms of EM interference which plague electrical transmission [Hughes and Lonie, 2007].

Thus far, the implementation of the Tanzania National IP backbone network which started in June, 2015 completed in January, 2016. This network that has been designed to withstand emergency failures, consists of planes A and planes B which apart from being redundancy of each other, work together to balance traffic. This network is being linked to the newly built Government Internet Data Centre [NICTBB 2016].

2.4 Advantages of Fibre in Tanzania

NICTBB has the following advantages; Reduction in Transport, Travel and Distribution costs: ICTs applications enable efficient communication online, where information and reports can be shared amongst members without physical gathering, meetings can be held remotely, and some assignments can be carried out from homes or without necessarily travelling all the way from homes to the work places or in another country, particularly in cities where traffic jams are order of the day [Lange, 2009]. A typical example of heavy traffic congestions is the Dar es Salaam City. “Every month with 22 working days, Dar es

Salaam city residents lose three hours a day, making it a total of 66 hours, which is equivalent to 792 hours per year in traffic jams [TCRA, 2010]. It is equivalent to one tenth or 10% of the worker's active life. For an average worker, paid a monthly salary equivalent to US$ 450, or US$ 20.50 per day, or US$ 2.60 per hour, his/her employer loses US$ 169 per month per employee, leave alone other loses due to fuel consumption, tear and wear and depreciation of a car or a bus. All these have negative impact to the national economy but with ICTs applications, these challenges can be addressed [Karjakina and Semtsenko, 2010].

E-government services; these includes e-services comprising of e-education, e-schools, learning, online studies, e-health, Tele-medicine, e-agriculture, e-tourism, e-procurement, and other applications such as video conferencing. With introduction of video conferencing facilities between MDAs, a lot of cost saving would be realized [Srai and Gregory, 2008]. For example; the Government would save hundreds of millions of money if video conferencing facilities were used to provide communication services between officials who are supposed to travel from Dar es Salaam all the way to Dodoma to submit a few copies of report documents to Members of Parliament who spend almost 3 months discussing Government Annual Budgets [Lange, 2009].

The intervention of building the National Information Communications Backbone [NICTBB] provides robust platform whereby government, business, civil society, and international organization initiatives and interventions can coexist. Mainstreaming the ICT for achievement of Tanzania Mission Vision 2025 and realizing the Millennium Development Goals [MDG] must quickly be diffused by hard data connectivity, on development impact and the real potential to scale and up and replicate process of Last Mile connectivity [Wellenius, 2003].

2.5 Contribution of the Telecommunications Sector to the Development in Tanzania

Telecommunication sector pay a meaningful contribution to economic and social development in Tanzania. Apart from communication facilitation, telecommunication companies now offer money transfer and servings, by so doing, telecommunication

companies' foster economic development in Tanzania. According to Helpman, [2012], telecommunication sector assist the development of investments, attract Foreign Direct Investment [FDI] and creates the opportunities for economic growth and development.

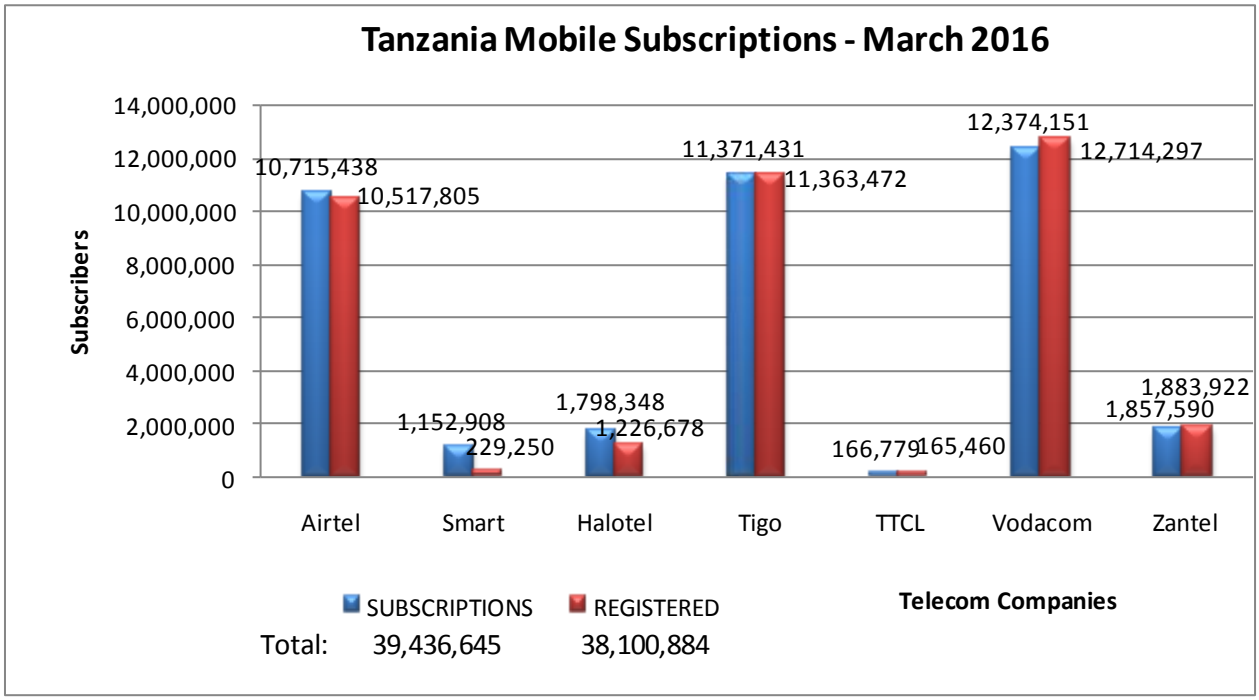
Tanzania has a fully competitive telecommunications sector. There are two fixed-line operators and seven operational mobile networks, with four additional players licensed. The national fixed telephone operators are the TTCL and Zantel. They also offer national and international mobile telephone services. The TTCL fixed-line network has been digital since 2004. However, teledensity for fixed-line has remained extremely low, with only around 300,000 lines installed and many out of service. The TTCL offers Integrated Services Digital Network [ISDN] with Basic Rate Interface, Primary [Mfungahema, 2006].

Since the connection of the country to the international fibre-optic cable [SEACOM], new services and products have been introduced [Cameron, 2011]. Currently, the TTCL offers voice services which include Bongo Phone, Prepaid Services, Prepaid Calling Card, Post Paid Services, Rafiki Public Phone, and TTCL Mobile. Data communication services include broadband, wireless broadband, Mobile Internet, Virtual Private Network [VPN] providing dedicated end-to-end connectivity to multiple sites in different geographical locations with scalable and guaranteed bandwidths of 64Kbps to 100Mbps, and leased digital and analogue circuits. Zantel is based in Zanzibar, but with the liberalization of the market got license coverage to the mainland. It has a fixed-line and mobile telephone network. Zantel is fast penetrating the mainland, offering lowest rates in fixed, broadband and mobile telephony. Zantel offers mobile banking branded Z-Pesa [Lange, 2010]. By the end of 2016, TTCL, Vodacom, and Tigo have launched a 4G services in some parts of Tanzania [TCRA 2016].

While the number of mobile uses is growing [ITU, 2014], the Tanzanian mobile telephone market is the fastest growing sector, with more than 23 million subscribers in a population of about 43 million. The major operators are Vodacom, Zain, TiGO and TTCL-mobile, Zantel-mobile and Halotel [TCRA, 2016]. While bandwidth may have

been a problem, there are many other factors that contribute to Tanzania's low Internet penetration and use. This situation may call for research based information and home-grown solutions to sustainable use of the Internet for development [Mfungahema, 2006].

With regard to Internet access and use, Tanzania lacks comprehensive data giving details of Internet users across the country. The data available is mainly aggregated from Internet café surveys and this does not depict the real situation of Internet usage. The number of telephone users has grown exponentially in the last 5 years to over 39milion by mid-2016 [TCRA 2016].



Telephone users; Source TCRA 2016.

Furthermore, TCRA estimates that in Tanzania there are over 11 milion internet users, which can be viewered as conservative estimates as a good number of mobile users can now access internet from their phones.

METHODOLOGY ADOPTED

The study was conducted in Tanzania's telecommunications companies based in Dar es Salaam since most of the companies have their headquarters located in the city. This study used both a qualitative and quantitative research approaches. Both approaches were used so as to complement each other and overcome the weaknesses of a single design, therefore enhance validity. Therefore, a case study research design was used in this study because the researchers intends to gain a deep and thorough understanding of the phenomena and because of its flexibility of the data collection methods. Also this approach was used because participants come from a single case, also an experimental study design is not appropriate because there was no random assignment of participants into control and treatment groups.

For the purpose of this study, staff from private and private companies, ministry and regulators were involved. Their roles in the industry and their experience meant that they collectively had materials rich for the study. The sample size of the study includes about 95 respondents from telecommunication companies, the sample was selected because there is a few number of employees; therefore this is a representative sample according to the nature of the study. The sample size indicated in the table below

Table 1: Sample Size Distribution

Areas	Number of Respondents
Engineer	47
Supervisor	14
Other employees	34
Total	**95**

The researchers prepared questionnaire, structured and unstructured questionnaires and were administered to participants. The researchers also prepared the interview guide questions in connection to research questions.

Secondary data collection will involves, documentary review. A number of documents

including official documents from telecom companies, Government departments, reports and seminar papers in relation with the problem were reviewed to supplement the primary data collected by the researcher. Documentary review guide was used as an instrument during data collection from different documents.

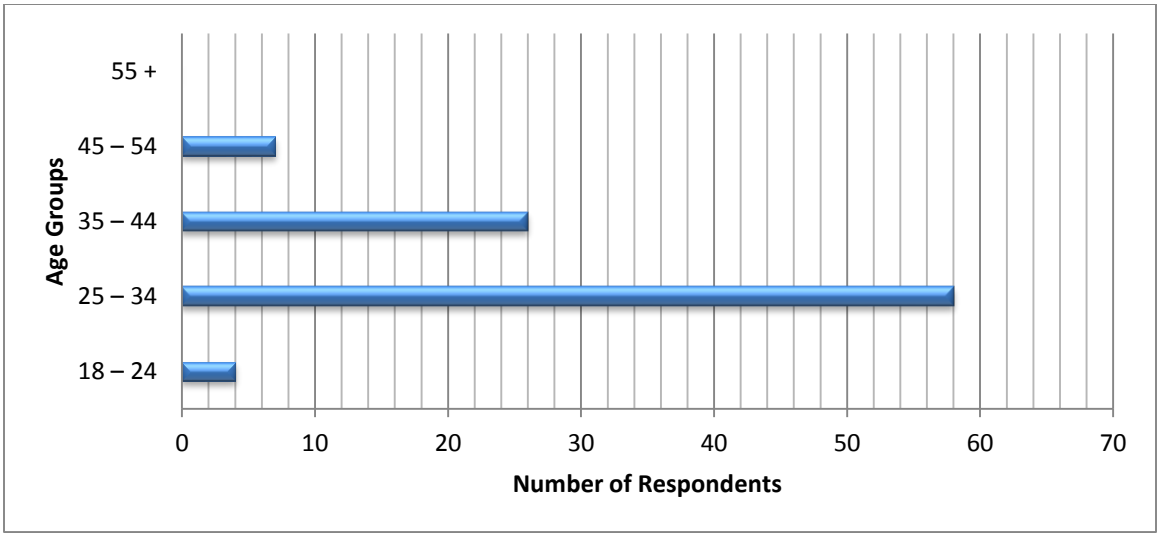
Data was analysed in accordance with the objectives of the study. Qualitative data will be collected and processed, Qualitative data refers to data representing qualitative phenomenon, example phenomena relating to or involving quality or kind. Editing was done immediately after receiving questionnaire from respondents. Coding was done in order to ensure whether the response categories were appropriately classified and exhausted to the problem under the study and arrange data collected according to group or classes they base on the basis of their common characteristics. Tabulation was done to assemble data into concise and logical order. The researchers analysed data collected qualitatively where words were used to explain findings and quantitative analysis where the data used numbers, computation of total and percentages, data analysis will be based on research objectives.

THE FINDINGS

Background characteristics of the respondents were asked in terms of age, occupations and working experience. It's important to establish the respondents profile in order to determine the capability of the respondents to participate in the study.

The study found that, majority of the respondents (61.1%) was aged between 25 to 34 years. This implies that majority of the experts in telecommunication sector are aged between 25 to 34 year. Furthermore, this suggests respondents are capable to provide responses for the study, therefore their opinions were considered. The study found out of 95 respondents 4, (4.2%) was between 18 to 24 years old. Also the study found undersized number of the respondents (27.4%) and (7%) were aged between 35 to 44 years and 45 to 54 years respectively. The study found majority of the respondents (61.1%) were aged between 25 to 34 years, as illustrated in Figure 4.1

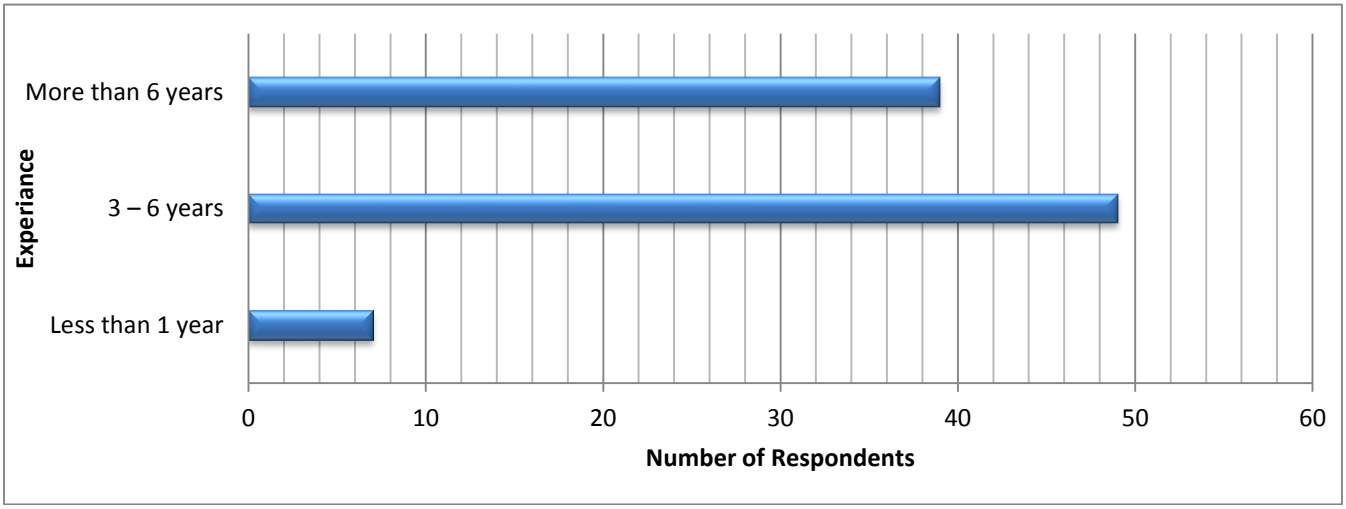
Figure 4. 1: Age of the Respondents



Source: Field Data.

The study found that the lager group of the respondents (49.5%) were engineers. This implies that, respondents were capable to participate in the study. Furthermore, the study found that majority of the employees (51.1%) has the experience of 3 to 6 years. This implies majority of the respondents were capable to provide responses, therefore their opinions and suggestions were considered. Moreover, the study found, minority of the respondents (7.4%) and (41.1%) have the working experience of less than one year and more than 6 years respectively, as illustrated in Figure 4.3 below

Figure 4. 2: Working Experience



Source: Field Data, 2013

The Status of Fibre Infrastructure in Tanzania and East Africa

The study was interested to examine the status of fibre infrastructure in Tanzania and East Africa. In terms of total kilometre covered, it's discovered that, fibre infrastructure has satisfactory coverage, 7560km, 2000Km in Rwanda, 4233Km in Kenya (private) and Uganda 2000Km.

> *"We cover 21 regions except SIMIHU in Shinyanga, it has a single POP in these regions and hence only one drop off point where the Service Provider/client must connect. We cover all the major boarders and have POPs in the bordering countries".*

This is similar to responses obtained during interview, one of the interviewed expert from the ministry, revealed that:

> "*A total of 7560km is covered in Tanzania, where 2112km are from TANESCO and 5448km were built for this project. In EAST AFRICA: 2000Km in Rwanda, 4233Km in Kenya [private], Uganda 2000Km and Burundi are having plans to build"*

In terms of region covered in Tanzania the fibre infrastructure has good coverage. It's found the large part of the country it's covered with fibre infrastructure. It's discovered that the requirements of the telecommunication companies are; 2xSTM-16 P-t-P unprotected, 5×STM-4, 12×STM-1and 1Gbps (1000Mbps or 7 STM1). Moreover, various reasons were found to be the factors for NICTBB to meet capacity required.

> *"We meet capacity required by the telecommunication companies because; a designed capacity of NICTBB is 400G whereas the installed capacity [boards] 20G, used capacity is still only10G"*

Factors Which Cause Low Utilization of the NICTBB

The study was interested to determine factors which cause low utilization of National ICT broadband backbone. Respondents were required to identify factors which cause low utilization, in their reply the study found majority of the respondents (67.78%) identified high price, as presented in figure 4.5. The study found majority of the respondents (58.9%) identified lack of demand as the major factor impedes full utilization of National ICT broadband backbone. This is similar to respondents obtained during interview, on of the interviewed engineer of the telecommunication company revealed that:

> *"I think lack of Public awareness about National ICTBB is a major cause of low utilization of the fibre. Also Government itself doesn't utilized fully the use of ICT-Supposed to be a big customer, no connection to last miles, Mobile Companies have invested more on wireless TRM infrastructures already. To let private company build their own fibre Network. Example, VTL built from Dar-Dodoma"*

Moreover the study found significant number of the respondents (67.8%) stated high price hinder full utilization of the NICTBB. In fact high price impede small telecommunication companies to use NICTBB. Insignificant number of the respondents (28.9%), (24.4%) and (20%) identified, lack of local contents, unfavourable government policies and lack of demand as a factors which cause low utilization.

Furthermore, the study found out of 90 respondents 36 (40%) identified as a major factor hindering full utilization of the NICTBB. The study found small number of the respondents (17.8%) stated lack of technical skills as a factor hinder full utilization. Also, it was found out of 90 respondents 14 (15.6%) and 16 (17.8%) identified poor design and poor after sale support respectively. As illustrated in Figure 4.5

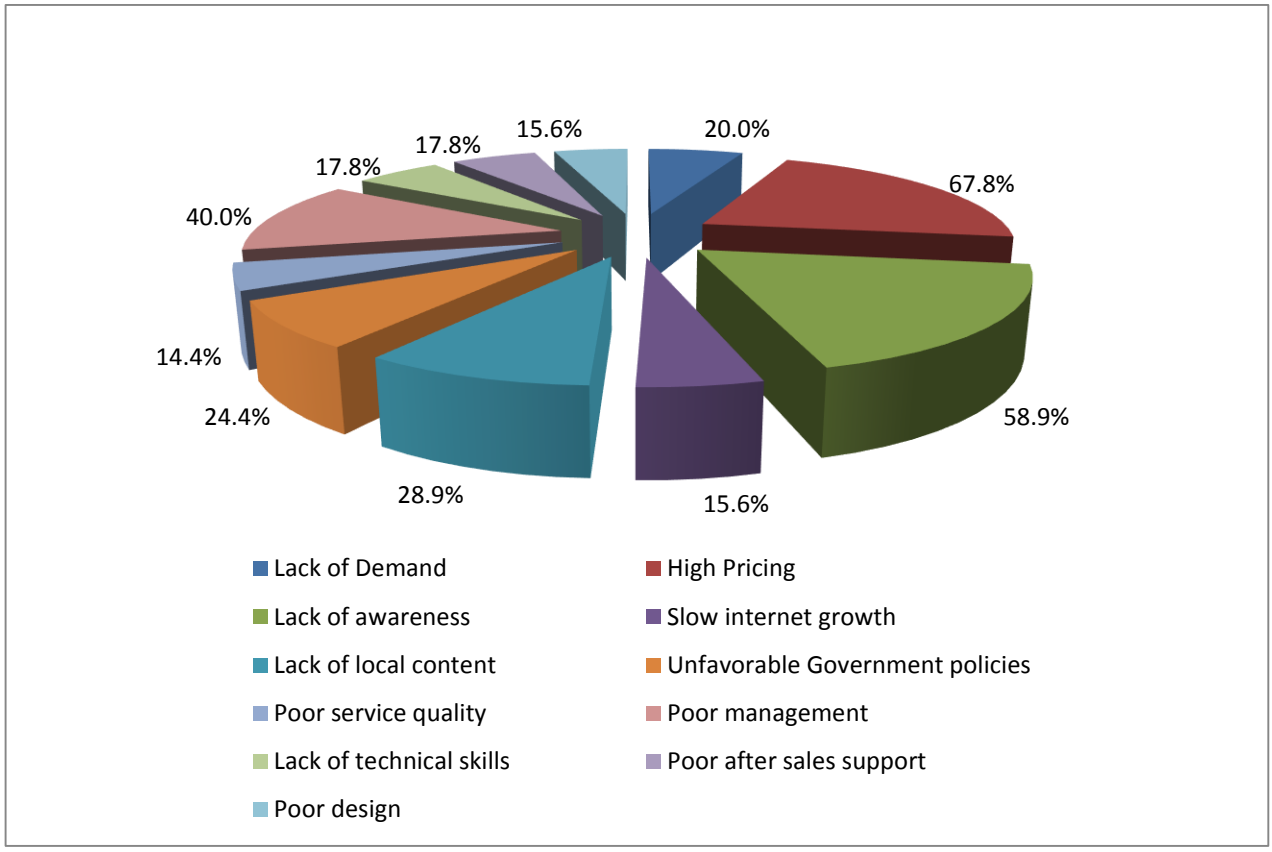


Figure 4. 3: Factors Which Cause Low Utilization. Source: Field Data, 2013

Factors that can foster full utilization of the NICTBB, the study was interested to examine factors that can foster full utilization, respondents were asked to identify factors. In their reply the study found majority of the respondents (67.8%) suggested lowering price could foster full utilization of the NICTBB, as presented in figure 4.6.

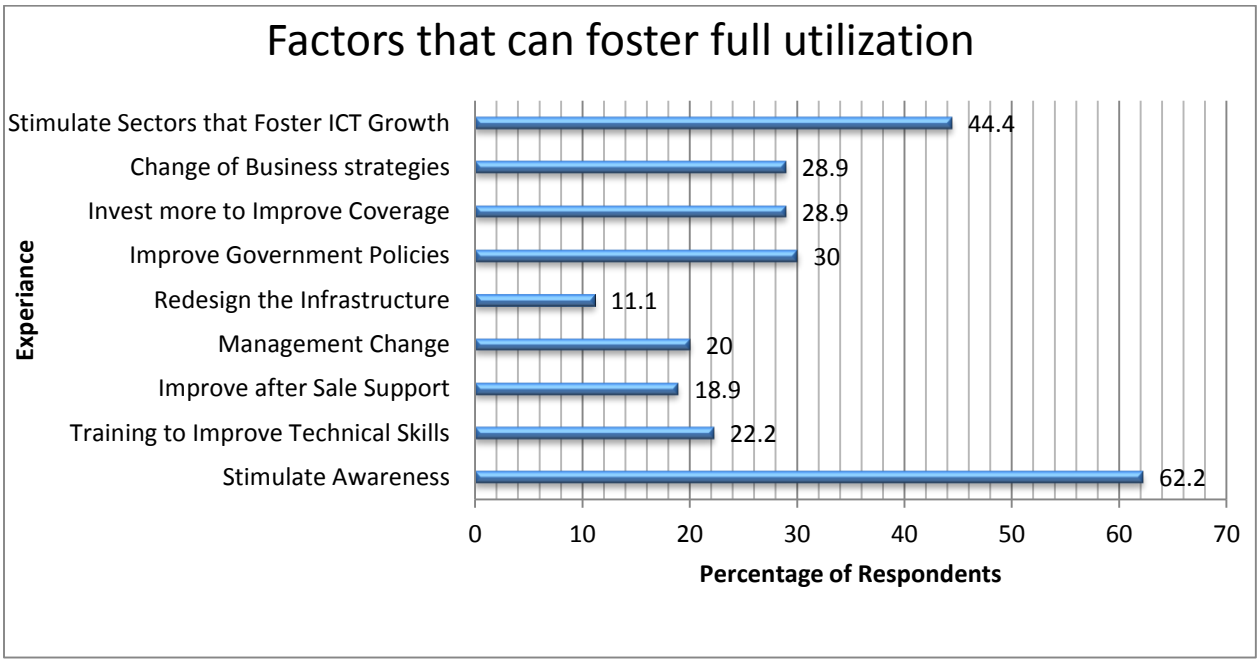


Figure 4. 6: Factors that can foster full utilization

The study found majority of the respondents (67.8%) identified lowering price could foster full utilization. Respondents suggested that NICTBB should review and implement a lower tariff rates plus a good capacity provisioning timelines. Also the study found significant number of the respondents (62.2%) stated NICTBB should stimulated awareness to foster full utilization of the fibre. This is similar to what observed during interview, one of the respondents revealed that:

> *"There is a need of increase awareness to public to foster full utilization of the NICTBB. Also the Connectivity prices should be regulated and affordable to huge number of users, Special rate to Government institutions and research centres. Moreover, joint arrangement with a Consortium of Operators and Government, this will reduce investment cost and hence make commercially realistic"*

Also the study found out of 90 respondents 40 (44.4%) stated there is a need of stimulate supporting sectors that foster ICT growth. The study found small number of the respondents (11.1%), (18.9%) and (22.2%) identified, redesign the infrastructure, improve after sale support and training to improve technical skill respectively.

Effects of low utilization, the study were interested to assess the effects of low utilization of NICTBB. Respondents were asked to identify the effects of low utilization, in their respond the study found out of 90 respondents 32, (35.6%) identified low utilization hider ICT growth, as shown in Figure 4.7

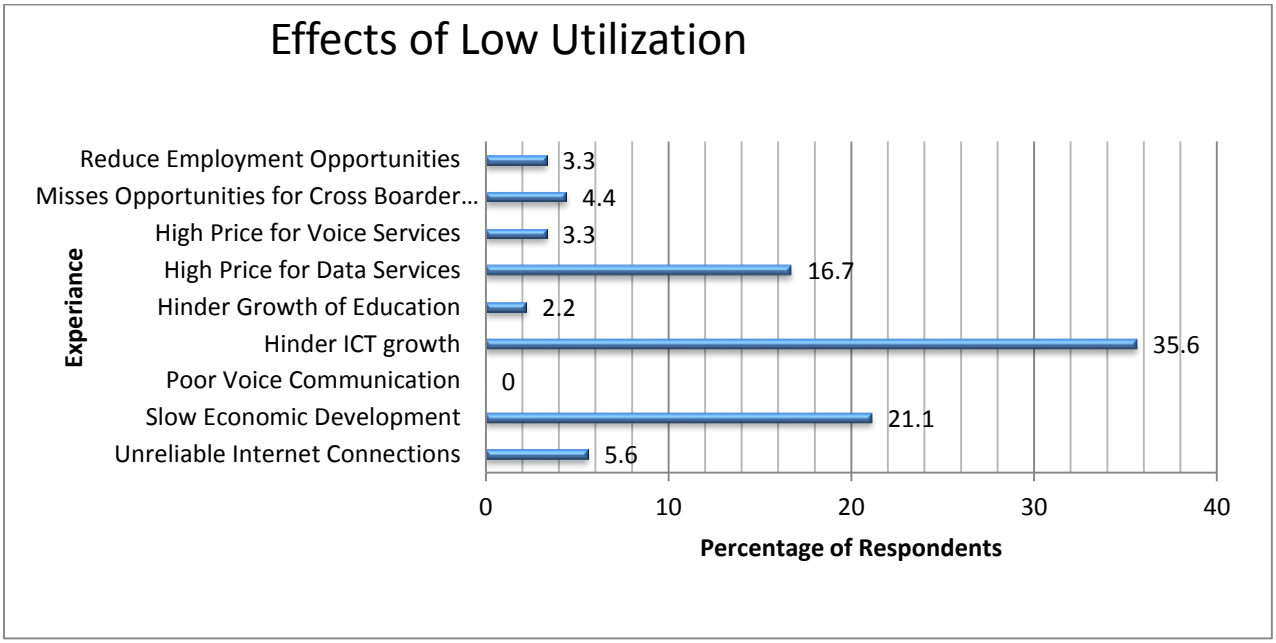


Figure 4. 7: Effects of Low Utilization; Source: Field Data, 2013

The study found out of 90 respondents 32, (35.6%) identified low utilization hider ICT growth. This implies that, low utilization of the fibre infrastructure has unenthusiastic impact on ICT growth. Moreover, the study found small number of the respondents (3.3%) and (16.7%) identified high price for voice services and High price for data services respectively. This is similar to findings obtained during interview. One respondent from the ministry started that:

"Low utilization of the fibre infrastructure hinder ICT growth and high pricing for data/voice services, Lower quality Data/voice services and Missed business opportunities via ICT development [e government, e commerce etc] Hamper innovation due to bandwidth bottlenecks"

Moreover, the study found insignificant number of respondents (21%) identified low utilization hinder economic development. The study found out of 90 respondents 7 (7.8%), (5.6%) and 3 (3.3%) identified slow data connections, unreliable internet connections and reduce employment opportunities respectively.

"The major weakness of the current strategies are; Tariff and Marketing strategies, Internal Procurement process between NICTBB and its Project Manager [TTCL] and Vulnerability of OSP network infrastructure to frequent FOC damages/cuts"

Strategies to Improve the Applicability of the National ICT Broadband Backbone

The study was interested to assess strategies that can improve the applicability of the National ICT broadband backbone. Respondents were required to identify the weakness of the current strategies. It was observed that of 87 respondents only 17 (19.5%) identified project mission. Also the study found small number of the respondents (22.9%) and (10.3%) identified project vision and choice of the technology. This is different from what observed during interview. Moreover, the study found significant number of respondents (51.7%) identified Positioning (Product and Target Customers) as a major weakness of the current strategies. this is well illustrated in Figure 4.8

One of the interviewed engineers stated that:

"The major strategies that are current applied involve; Work in close coordination with the regulator [TCRA] to ensure the community rips the benefits of NICTBB example tariff drop for off net is a result of diminishing costs brought by the NICTBB which has allowed TCRA to lower the price ceiling, also Capacity will be increased to 120G and We work in close coordination with TTCL to ensure efficient delivery of services and identification of any

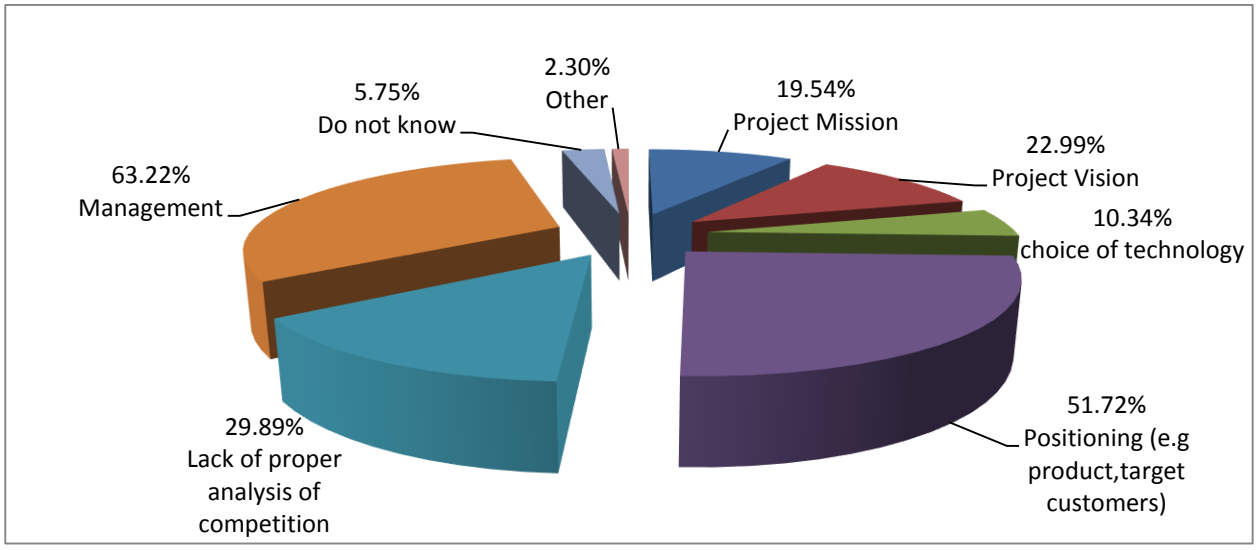


Figure 4. 4: Weakness of the Current Strategies

ANALYSIS AND DISCUSSIONS

5.1 The Status of Fibre Infrastructure in Tanzania and East Africa

The study was interested to examine the status of fibre infrastructure in Tanzania and East Africa. The study found out of 90 respondents 40, (44.4%) identified the coverage of the fibre infrastructure is satisfactory. This implies that the status of fibre infrastructure in Tanzania and East Africa is acceptable.

Although the status of fibre infrastructure in Tanzania and East Africa is convincing the infrastructure remains tangible coverage to rural and remote areas. In Tanzania the fibre infrastructure covers all regions except Simiyu. All regions have one POP, This is observed to be a major challenge impede the efficient of the fibre infrastructure. In East Africa, 2300Km are covered in Rwanda, 4233Km in Kenya (private), Uganda covered 2000Km and Burundi are having plans to build. This implies the coverage of the fibre infrastructure in Tanzania is superior compared to other East African countries

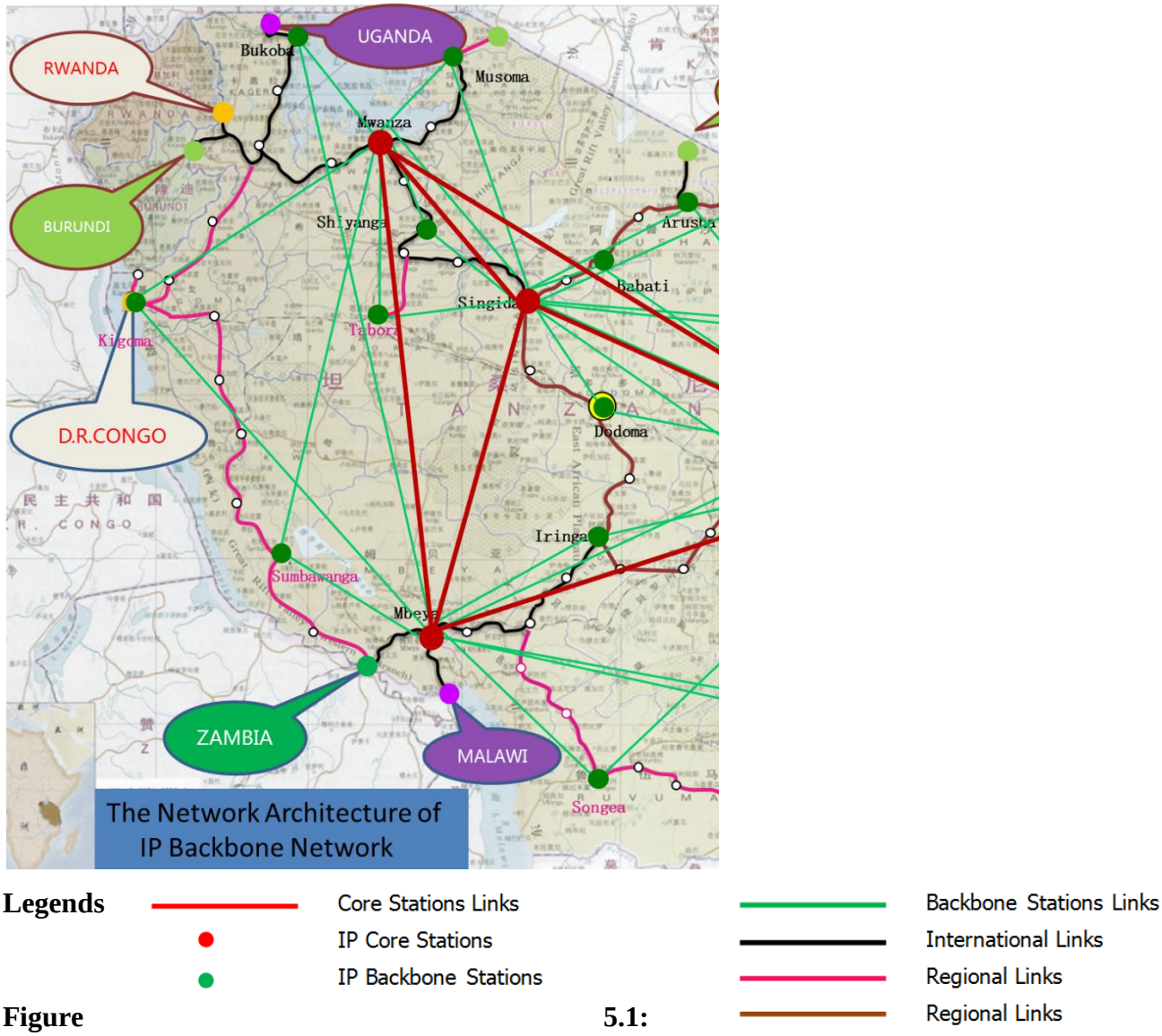


Figure 5.1: Fibre coverage map in Tanzania (NCITBB 2016)

The NICTBB was designed to have a maximum capacity of 400Gbps based on the chassis of the active components. The installed capacity is currently at 20Gbps. The next phase will involve an upgrade to 120Gbps based on the global growth for data and demand from clients.

Moreover, study was interested to examine the National ICT Backbone capacity requirements. The study found majority of the respondents (56.7%) accepted that the fibre infrastructure meet required capacity, this implies the fibre infrastructure met the required capacity of its current clients. Despite the massive growth of the internet and

global data growth, the NICTBB is not being fully utilized to its full potential. The study found, the backbone is currently operating at less than 50% of its installed capacity and 2.5% of its design capacity.

NICTBB met current capacity required by its clients, It's discovered that major requirements came from the telecommunication companies are; 2xSTM-16 P-t-P unprotected, 5×STM-4, 12×STM-1 and 1Gbps (1000Mbps or 7 STM1). Telecom companies currently comprise approximately 90%of the total capacity being utilized on the NICTBB.

5.2 Factors Which Cause Low Utilization of the NICTBB

The study was interested to determine factors which cause low utilization of National ICT broadband backbone. There were a number of factors which cause low utilization of the fibre infrastructure. The lack of demand, poor management, high pricing, lack of awareness, slow internet growth, lack of local contents, unfavourable government policies, poor service quality, poor management, lack of technical skills, poor after sale support and poor design of the fibre infrastructure.

The study found majority of the respondents (67.8%) identified high pricing as the major factor which impedes full utilization of National ICT broadband backbone. The underutilization is due to low purchasing power of the consumers which means the service providers have to match supply, demand and market pricing and fit in required margins. It is a fact that high pricing impede small telecommunication companies to use NICTBB. This reduces the overall demand for National ICT broadband backbone.

Furthermore 40% of the respondents identified poor management as a cause of the underutilization. Most high level managers who have worked with NICTBB through its care taker (TTCL) found many challenges during procurement and operation of the IRU capacities. Many cross boarder operations also believed it was difficult to work with the current manager suggesting that a lot could improve if a managerial assessment is made.

Moreover, the study found that 28.9% attributed the lack of local content to be a cause for

the underutilization. Most of the data received by the Tanzanian market is hosted outside the country and thus requiring massive capacities to the internet using operators such as SEACOM and EASSY who have hubs in Dar es Salaam. This suggests that local content stored in different parts of the country would have accelerated the requirement for utilizing the NICTBB.

Above all, the study was interested to examine factors that can foster full utilization, respondents were asked to identify factors. The study found majority of the respondents (67.8%) suggested lowering price could foster full utilization of the NICTBB, 62.2% of the respondents suggested to stimulate awareness by marketing, 44.4% advised to support supporting sectors to foster ICT development and increase the utilization. Overall there are various factors that can foster full utilization of the fibre infrastructure. These involves, lowering price, stimulate awareness, training to improve technical skills, improve after sale support, management change, redesign the infrastructure, improve government policies, invest more to improve coverage, change of business strategies and stimulate sectors that foster ICT growth.

5.3 Strategies to Improve the Applicability of the National ICT Broadband Backbone

The study was interested to assess strategies that can improve the applicability of the National ICT broadband backbone. The study establish the weakness of the current strategy, the study found majority of the respondents (63.2%) identified management as a factor that contribute to weakness of the current strategies. This implies, the management of the National ICT broadband backbone, is not well performed, the reasons for this could be, the management of the National ICT broadband backbone are not well trained in business aspects. Management is concerned with the establishment of the strategies, therefore should be well trained and full equipped.

The Government of Tanzania has mandated Tanzania Telecommunication Company Limited (TTCL) to supervise project implementation and management of the NICTBB. But a lot of complains were observed from telecom operators due to poor management of

the National ICT broadband backbone

Furthermore 51.7% suggested there is a need to redefine the positioning aspects of the business. This calls for a need to properly identify the targeted market, currently NICTBB targets the service provider but the customer base suggests only large service providers such as telecom companies are able to invest in the IRU requirements on the NICTBB. Positioning also means making sure the correct product is available to serve different customer needs.

Additionally, 29.9% acknowledge the need to review the completion better. Any business has competitors and pricing alone cannot be a competitive advantage. Currently there are private fibres being built by operators some individually e.g. Vodacom with fibre to Dodoma others forming consortiums. Analysing the competition will allow the NICTBB to be more strategically aligned with the market environment and ultimately increase utilization and profits.

Other factors that contributes contribute to weakness of the current strategies, involves; project mission, project vision, choice of technology, positioning (product and target customers), lack of proper analysis of competition and management. This implies project mission and vision were note well designed in line with purchasing power of the telecommunication companies. Moreover, the product is not well positioned by targeting customers.

Furthermore the study found different strategies that are current applied by NICTBB, this involve; Work in close coordination with the regulator (TCRA) to ensure the community rips the benefits of NICTBB example tariff drop for off net is a result of diminishing costs brought by the NICTBB which has allowed TCRA to lower the price ceiling, also capacity will be increased to 120G. But this is not enough without considering the purchasing power of the telecommunication companies.

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Based on the findings of the study, the study concluded that the status of the NICTBB is satisfactory in terms of coverage to the major towns. However, last mile connectivity is still a challenge. By end of 2015, NICTBB covered all the regions of the country. Generally, comparing the NICTBB status in Tanzania with other East African countries, coverage is much better with exception of Rwanda which has more coverage if size is taken into account. The study concluded that price is a major reason for underutilization of the fibre infrastructure, other factors include; poor management, lack of awareness, slow internet growth, lack of local contents and unfavourable government policies.

Moreover the study concluded that, there are different strategies that are applied to foster utilization of the fibre infrastructure. Despite the fact that the Government of Tanzania used a lot of money for installation of NICTBB but utilization is still very minimum and operational cost won't change much with increase in utilization. This is due to the scanty knowledge and public awareness about NICTBB. It implied that few people know about or existence of NICTBB, but most of them they don't know the advantage and disadvantage of this NICTBB.

Another challenge is the lack of local contents was found to be one the reason for low utilization. Government itself is yet to start getting basic services to citizen via ICT. Schools for example, could be the major traffic creator if students were accessing knowledge whilst utilizing the backbone. Properly used and coordinated will bring the desired effect and passing the knowledge information to the public as anticipated. By sharing backbone network infrastructure, builders of backbone networks can reduce costs, improve quality and gain profits. This will reduce the need to make such heavy investments as those borne by investing in fibre privately or via consortiums. This is particularly relevant for fibre-optic networks in urban areas, where the costs of laying new fibres can be high, or in the rural areas; where the revenues generated by such networks are low.

6.2 Recommendations

The authors recommend that the government promote the use of the network by creating awareness campaign. It should also set special rates for institutions that drives public services such as education establishments. It is also suggested that government should create a world class data centre and initialise a special project to create local contents. This will create a cloud like systems where organisation will plug into the data centre to access knowledge, entertainment etc.

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