KNAPSACK PROBLEM

A CASE STUDY OF METRO T.V., A TELEVISION STATION IN GHANA

BY

AKYEA SETH NTOW

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DECLARATION

I hereby declare that this submission is my own work towards the master of Science degree and that, to the best of my knowledge it contains no material previously published by another person nor materials which has been accepted for award of any degree of the University except where due acknowledgement has been made in the text.

Akyea Seth Ntow 20127304	………………………	……………………
Name & student's number	Signature	Date

Certified by,

Prof. S.K. Amponah	……………………..	……………………
Supervisor	Signature	Date

Certified by,

Dr F.K. Darkwah	………………………	……………………
Head of Department	Signature	Date

DEDICATION

This piece of work is dedicated to my mom Martha Amma Opokua, my wife; Vivian Dansoa, and children, Emmanuel Ntow Akyea, Enoch Opoku Akyea and Magdalene Amponsah Akyea.

AKNOWLEDGEMENT

No one ever writes a book 'by oneself' and in my case this is particularly true. Knapsack Problem, a case study of Metro TV has come to be, not through my ideas alone, but that of many people who gave their time, talents and ideas.

Specifically, I am indebted to Prof. S. K. Amponsah, my supervisor and lecturer at Kwame Nkrumah University of Science and Technology (KNUST) for taking pains to read through this write-up and offering editorial and helpful critical evaluations. To all the Lecturers of Industrial Mathematics, I say, "Thank you for your suggestions." I also want to make mention of the late Mr. Agyemang; "You were indeed an inspirer."

No one can calculate the gratitude family members deserve when a researcher is researching. My debt of gratitude goes to my wife and my children for patience and utmost support.

And in all these, to God be the glory.

ABSTRACT

The Knapsack or Rucksack problem is a problem in combinatorial optimization. Though the name existed in folklore, it might have been derived from the maximization problem of the best choice of essentials that can fit into a bag to be carried on a trip. Supposing a traveler has a traveling bag (knapsack) that takes a maximum of b_{kg} of “items.” The traveler has n items (1,2,3, …, n), they weigh w_j and are of value c_j to him. How many pieces of items should be placed in the knapsack so as not to exceed the maximum weight of “b”? The practice of selecting commercials to be played on air from a pile of commercials in most TV and radio stations to generate the maximum revenue given a fixed time, is a clear case of Knapsack problem. In this research, our interest is in the systematic and efficient way of organizing adverts on Metro TV, a TV station in Ghana, with the help of the Heuristic Scheme (simple flip) proposed by Amponsah and Darkwah (2007), a variant of the classical 0-1 Knapsack problem to maximize income. Nevertheless, our methodology focuses among others, on general techniques such as Simulated Annealing, Genetic Algorithm, Branch-bound Method, Dominance Relations, Dynamic Programming and thus may be applicable in implementation of the Knapsack problem. We also pointed out some reasons for the good practical performance of our algorithm. A computer solution developed in Visual Basic Dot Net employed in analyzing the data collected from Metro TV can be used for any problems that can be modeled as a single 0-1 Knapsack problem. The results of the analysis of data showed a 35.19% increase in income of the station; from GH¢21,000.00 when adverts were selected arbitrarily to GH¢28,390.00 daily, at the time the software was used.

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CHAPTER ONE

1.0 INTRODUCTION

Problems many individuals, homes and industries face are allocating limited resources (including their money, time, space etc) to specific investments for maximum returns. It may also involves packing of items at home into containers such as suit cases, arrangement of office equipments, the packing and or movement of industrial products from the industry to the distribution points among others.

It is therefore obvious that everyone is involved in parking in one way or the other. These allocations when done well, not only ensure beauty and attractiveness but also, efficient usage of space, time and energy.

Imagine you have a bunch of objects of various values and weight from which you have to select any number to fit into a container. Your goal is to create the most valuable collection possible without of course exceeding the allowed weight capacity. These problems are called the knapsack problems since they recall the situation where a traveler has to fill up his Knapsack by selecting from among various possible objects those which will give him maximum comfort.

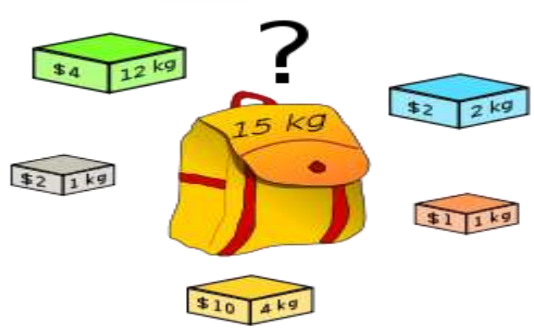


Figure 1.1: knapsack problem

(Which item should be placed in the knapsack for maximum returns?)

A great variety of practical problems can be represented by a set of entities, each having an associated value from which one or more subsets would have to be selected in such a manner that the total of the value of the selected entities is maximized under certain constraints.

Among the resources of broadcasting houses (both radio and television) is time.

The Television houses have to program intermittently with advertisements or commercials which are the main source of income for them. These adverts are arranged so well as to attract wider audience for maximum income

1.1.0 BACKGROUND OF THE STUDY

1.1.1 HISTORY OF RADIO IN GHANA

Radio Broadcasting began in the Gold coast as relay service, rebroadcasting programmes from the BBC world service. A year later, the service began to expand and a re-diffusion station was opened in Cape Coast, now the central regional capital of Ghana to cater for that part of the country. This was followed essentially by three more stations the following year. Also, a broadcasting house was built in Accra with an installation of a small 1.3kw transmitter in 1940. This helped, not only to expand transmission to neighbouring institutions, but also, start broadcasting in four major Ghanaian languages. They are Twi, Fanti, Ga and Eve. In 1952, however, the colonial government appointed a commission to advise it on ways of improving and developing broadcasting. It was mandated among other things to investigate the establishment and maintenance of a statutory corporation to assume direction and control of broadcasting service as was the case in Great Britain. As a result of the commission's report, a new broadcasting system; the national service of the Gold Coast Broadcasting system was commissioned in 1954. Broadcasting content was mainly governmental announcements and rebroadcasting from BBC.

In 1956, locally produced programmes increased with the introduction of educational broadcasting to schools and Teacher Training Colleges. Outside events were broadcast live to homes. When the Gold coast gained independence in 1957, the Gold Coast broadcasting system became the Ghana Broadcasting systems or as it was popularly referred; Radio Ghana. (www.Ghanaweb.com)
But by the 1980's, state monopoly of mass media in Africa was beginning to wane. Since the introduction of radio by the then governor; Sir Arnold Hodson in the Gold Coast in 1935, it was not until 1992 that the change in constitution of Ghana paved way to private access in owning the facility.

This, not only resulted in the springing up of private radio stations in Ghana, but also, the extension of the state owned radio stations to all regional capitals across the nation. Currently, there are about 180 radio stations of both government and private owned in the country. Here are the regional FM stations of the government

Table 1.1: Regional Fm Station

NAME OF STATION	CHANNEL	TOWN	REGION
Obonu FM	96.5 FM	Tema	Greater Accra
Unique FM	95.7	Accra	Greater Accra
Garden City	92.1 FM	Kumasi	Ashanti Region
Radio Central	92. 5 FM	Cape Coast	Central Region
Twin City Radio	94.7 FM	Sekondi-Takoradi	Western Region
Sunrise FM	106. 7 FM	Koforidua	Eastern Region
Volta Star Radio	91.1 FM	Ho	Volta Region
Radio BAR	93.5 FM	Sunyani	Brong Ahafo Region
Radio Savanna	91.3 FM	Tamale	Northern Region
URA Radio	89.7 FM	Bolgatanga	Upper East
Radio Upper west	90. 1 FM	Wa	Upper West

1.1.2 BROADCASTING TV SYSTEMS

In the world today, there are several broadcasting television systems in use. These include the analogue, digital switch over and digital. These broadcasting stations are either state owned, private stations or pay stations.

1.1.3 ANALOGUE TELEVISION SYSTEM

An analogue television system include several components; a set of technical parameters for the broadcasting signal, a system for encoding colour and possibly a system of encoding multi-channel audio. In digital television all of these elements are combined in a single digital transmission system. All but one analogue television systems began life in monochrome. Each country aced with local political, political and economic issues, adopted a colour system which was effectively grafted onto an existing monochrome system, using gaps in and video spectrum to allow the colour information to fit in the channel allotted. In theory, any colour system could be used with any monochrome video system. But in practice, some of the original monochrome systems proved impractical to adapt to colour and were abandoned when the switch in colour broadcasting was made. The three types of colour systems in used are NTSC, PAL and SECAM.

Apart from colour, all television systems work essentially in the same manner. The monochrome image seen by a camera is divided into horizontal scan lines, some number of which makes up a single image or frame. A monochromes image is theoretically continuous and thus unlimited in horizontal resolution. To make television practical, a limit had to be placed on the band switch of the television signals which puts an ultimate limit on the horizontal resolution possible. When colour was introduced, this limit of necessity became fixed.

All current analogue television are interlaced, alternate rows of the frame are transmitted in sequence, followed by the remaining rows in their sequence. Each half of the frame is called a field, and the rate at which fields are transmitted is one of the fundamental parameters of a video system. It is related to the frequency at with the electric power grid operates to avoid flicker resulting from the television screen defection systems and nearby mains generated magnetic fields. All digital, or fixed pixel displays have progressive scanning and must de interlace an interlace source. Use of inexpensive de-interlace hardware is topical difference between lower-verses higher prices flat panel displays (PDP, LCD, LED etc)

All movies and other filmed materials shot at 24 frames per second must be transferred to video frame rates in order to prevent severe motion filter effects. typically for twenty five (25) frame(s) format (countries with 50HZ mains supply) the content is sped up, while a technique known as "3:2 pull down" is used for 30 frame(s) format (countries with 60HZ main supply) to match the film frame(s) to the video form without speeding up the display back. Analog televisions signals standards are designed to be displayed on a cathode ray tube (CRT) and so the physics of these devices necessarily controls the format of the video signal. The image on a CXRT is printed by moving beam of electrons which lits a phosphor coating on the front of the tube. This electrons beam is sleeved by magnetic field generated by powerful electromagnetic close to the source of electron beam in order to reorient this magnetic steering mechanism, a certain amount of time is required due to the inductance of the magnets; the greater the change the greater the time it takes for the electron beam to settle in the new spot.

For this reason, it is necessary to shut off the electron beam (corresponding to video signal of zero luminance during the time it takes to reorient the beam from the end of live to the beginning of the next (horizontal retrace) and from the bottom of the screen to the top (vertical retrace or vertical blanking interval. The horizontal retrace is accounted for as phantom lines which are never displayed but which are included in the number of lines per frame defined for each video system. Since the electron beam must be turned off in any case, the result is gaps in television signals, which can be used to transmit other information, such as test signals or other identification signals.

The temporal gaps translate into a comb-like frequency spectrum for the signal, where the teeth are space at the line frequency and concentrate most of the energy; the space between the teeth can be sued to insert a colour sub carrier. Broadcasters, later developed mechanism to transmit digital information on the phantom lines, used mostly for teletext and closed captioning.

PAL-Plus uses a hidden signaling scheme to indicate if it exists and if so what operational mode it is. NSTSC has been modified by the Advance Television standard committee to support and anti-ghosting signal that is inserted on a non-visible scan line. Teletext uses hidden signaling to transmit information pages. NTSC closed captioning signaling that is nearly identical to teletext signaling. All six hundred and twenty five (625) line system incorporate pulses on line twenty-three (23) that flag to the display that a 16:9 widescreen image is being broadcast, though this caption is not currently used as analogue transmissions. (www.ghanaweb.com)

RADIO SYSTERMS

1.2.4 AMPLITUDE MODULATION (AM)

A.M stations were the earliest broadcasting stations to be developed. A.M. refers to Amplitude

Modulation, a mode of broadcasting radio waves by varying the amplitude of career signals in response to the amplitude of the signal to be transmitted. One of the advantages of A.M is that, its unsophisticated signal can be detected, (tuned into sound) with simple equipment. If a signal is strong enough, not even a power source is needed; building an unpowered crystal radio receiver was a common childhood project in the early years of radio. AM stations were the earliest broadcasting stations to be developed. An AM receiver detects amplitude variations in the radio waves at a particular frequency. It then amplifies changes in the signal voltage to drive a loudspeaker or earphones. One of the advantages of AM is that, its unsophisticated signal can be detected, turned into sound with simple equipment. If a signal is strong enough, not even a power source is needed.

1.1.5 FREQUENCY MODULATION (FM)

Frequency modulation (FM) conveys information over a carrier wave by varying its frequency (contrast this with amplitude modulation, in which the amplitude of the carrier is varied while its frequency remains constant). In analog applications, the instantaneous frequency of the carrier is directly proportional to the instantaneous value of the input signal. Digital data can be sent by shifting the carrier's frequency among a set of discrete values, a technique known as frequency-shift keying.(Wikipedia, free encyclopedia). FM was invented by Armstrong in 1930s for the purpose of overcoming interferences (Wikipedia, free encyclopedia)

1.1.6 DIGITAL AND SATELITE RADIO

Digital and satellite radio are slowly emerging, but the enormous entry cost of space based satellite transmitters are restrictions on available radio spectrum licenses have restricted the growth of this market. Many other non-broadcasting types of radio stations exist. These include base stations for police, fire and ambulance networks, military base stations, dispatch base stations for taxi, trucks and careers, emergency broadcasting systems, amateur radio stations.

Radio has indeed contributed an appreciable percentage to the saying that the world is a global village. Global village in the sense that, journalists gather, evaluate and disseminate information of current interest and by the power of radio wave propagation and its widespread, people within a community, country, continent are fed with such information within the shortest possible time.

FM stations, due to their low running cost as compared to television and high patronage as compared to newspaper and even television, are able to attract a whole lot of audience. With the availability of portable radio sets one can listen to radio everywhere. In our offices, cars, market places, farms, etc the radio is seen as the friendliest medium educating, entertaining and giving braking news and also creating awareness. One may ask what then their source of funding is. They rely mostly on commercials or advertisements, sponsorships and advocacy. With the high increase of radio station in the country, the competition among these FM stations has become very keen and getting a lot of adverts to play a day to fund the station has become dependent on so many factors. Among these factors are getting a very high power antenna, having highly qualified presenters, knowing your target groups and coming out with programmes that can pull audience to the station. If all these are put in place, there will be a high probability of the inflows of adverts/commercials shooting up to the extent of pilling up. This pile-up comes as a result of so many customers wanting to advertise on particular programme and at a particular time. One can just image if a station has catchy programmes at all times. Many people would want to come in to sponsor, want their adverts to be played; for they know that is when they are going to get audience for their products and services.

This in fact becomes a problem especially when these programmes are also not well arranged. Bin Packing, an application that has recently gained grounds in the field of Mathematics has come to help solve some of these packing problems to ensure that the setbacks of FM stations, i.e. their inability to play all adverts/commercials because of poor packing of programmes, may be addressed. Their goal is to arrange programmes in such a way that optimal arrangement of programmes is attained within a fixed frame. This is the aim of this research.

1.1.7 THE DIGITAL TELEVISION TRANSITION

The digital television transition (also called digital switch over (DSO) or analog switch off (ASO) sometimes analogue sunset) is the process which analog television broadcasting is converted and replaced by digital television. This primarily involves both TV stations and over-the-air viewers; however it also involves content provider like TV networks, and cable TV conversion to digital cable. At the other extreme, a whole country can be converted from analogue to digital television. In many countries a simulcast service is operated where a broadcast is made available to viewers in both analog and digital at the same time. As digital become more popular it is likely that the existing analogue services will be faced out.

In the case of Ghana, the facing out of the analogue system has been slated for the 2013 to give way to the digital system.

The digital transmission is more efficient, easily integrating other digital processes, for features completely in available or unimaginable with analog formats. For the end-user, digital television has potential for resolution and sound fidelity comparable with blue-ray home video and with digital multiplexing, it is also possible to offer sub channels, distinct simulcast programming from the same broadcaster. For government and industry, digital television relocates the radio spectrum, so that can be auctioned off by the government. In the subsequent auctions, telecommunication industries can introduce new services and products in mobile telephone with internet, and other nationwide-telecommunication projects.

1.1.8 HISTORY OF TELEVISION IN GHANA

Television broadcasting began in Africa in October 1959 when the Western Nigeria Television (WNTV) was established and begun operation in Ibadan Nigeria. However, the first T.V. station established in Ghana is the state owned; Ghana Television (GTV) Operated by the Ghana Broadcasting Cooperation (GBC). It was inaugurated on the 1st July, 1965. Until 1985 when colour picture system was introduced, its operations were in black and white pictures. Due to its wide coverage and aims, it transmits programs in most languages in Ghana. They include: Dagbani, Ga, Twi, Eve, Hausa, Nzema, Fante etc

Since the lifting of the band on the operations of private owned media stations in Ghana in 1992, the influx of radio and TV stations is much appreciable. Currently there are three free-to-air channels of which one is state owned. The other two are TV3; Malaysian owned, which was launched in 1997 and Metro TV launched in 1997. Multi choice operates over 20 radio and TV channels. It provides its services through satellite as well as cable Gold, whose services through cable operates around Tema and its environs. Also Fontomfom TV which broadcasts in Kumasi. Apart from DSTV which is scatted in Ghana, TV AGORO (TVA) is also pay-TV Station but broadcast wavelengths over Accra; A banquet of six premium channels comprising news channel (CNN) Music channel (MCN) Cartoon Network for kids, Turner Classic Movies (TCM) and French channel (CFITV) They also broadcast two religious channels on 24 hour basis being Trinity Broadcasting Network (TBN) and Catholic Channel (EWTN) Currently most of the channels used in Ghana are on (VHF) But stations like (CNN) and others broadcast on UHF channels. The trend in TV broadcasting is towards use of more and more UHF channels because among other reasons they are more available. Other stations include

V-Net, Fantazia, TV-Africa launched in 2002, Viaset 1, Crystal TV, Ohenemedia, Top TV, Okyere city TV among others.

1.2 PROBLEM STATEMENT

The Knapsack problem goes as follows; imagine you have a bunch of objects of various values and weight from which you have to select any number to fit into a Knapsack. Your goal is to create the most valuable Knapsack possible without of course exceeding the allowed weight capacity.

Suppose a traveler has P items, the $_i$th item is worth q_i Ghana Cedis and weight r_i kgs. She wants to go with as much a load as possible, but she can only carry at most R kgs in his Knapsack. Here, P, q_i, r_i and R are all positive integers. Which items should be considered?

Furthermore, suppose a TV station wanting to broadcast b programmes. Each programme is worth c_i dollars and duration (time of broadcast) of t_i minutes. The station wants to broadcast as many programs as possible, but they can broadcast at most D programmes in a week. Here, p, c_i and D are all positive integers. Which programme should be broadcast?

This type of problem is known as the 0-1 Knapsack problem because each item has the same chance of being taken or left behind. The traveler cannot take a fractional amount of an item or items more than once. The Knapsack problem is an abstraction of many real problems from investing through telephone or transport routing to drilling holes among others.

1.3 OBJECTIVE

The objective of this research is to find an effective and efficient way of scheduling commercials or adverts in Metro TV to achieve the maximum returns. The main source of income for private operators of broadcasting is advertising, hence the need to research into the scientific means of selecting better options from the numerous adverts available to optimize income for their operations within the limited space of time.

1.4 METHODOLOGY

The method employed included literature review of major work on Knapsack problem taking into consideration methods employed in the solution of Knapsack problems and to develop computer solution for faster and efficient computation of the Knapsack problem of data from Metro T.V.

1.5 JUSTIFICATION

The advantage of providing both audio and visual in the form of information to radio and print media; which provides audio and visual only respectively makes TV stations not only an output of information but also attractive. TV provides output in the form of information, education and entertainment while creating employment to the general public.

It is therefore necessary that scientific measure be put in place in the selection of adverts from the numerous adverts to see to its continued growth.

1.6 LIMITATIONS

The problems to be considered in this survey are single 0-1 knapsack problems where one container must be filled with an optional subset of items. The capacity of such a container will be denoted by C. The more general case where m container of capacities c_i (i=1… m) are available is referred to as Multiple knapsack problem. The computer solution developed in VB Net programming language could be modified to solve multi-dimensional knapsack problem. Furthermore, other programming languages such as Matlab could also be used.

1.7 ORGANIZATION OF THE THESIS:

Chapter one provides the background of the Knapsack problems, history of radio and television industry, the methodology and justification of the Knapsack problem to solve the Television advertisement problem.

Chapter Two presents a review of relevant literature on Knapsack problem, applications and solution methods that have been proposed in literature.

Chapter three is devoted to some algorithms for the solution methods such as the branch and bound, the dynamic programming heuristics scheme, simulated annealing and Hybrid Genetic algorithm.

Chapter Four, deals with the collection and analysis of data from Metro TV in Ghana.

Chapter five outlines the findings and suggestions for future works.This chapter looked at formulation of Knapsack problem to solve TV advent problem.

1.8 SUMMARY

In this chapter, we have looked at the introduction, background of radio and TV broadcasting in Ghana, the methodology, justification and limitations of the thesis. In the next chapter, we shall put forward the review of works in 0 -1 Knapsack problems.

CHAPTER TWO

2.0 LITERATURE REVIEW

The pioneering work of Tobais Dantzig in the late 1850 has been followed by numerous researchers in the area of Knapsack problems (KP). These problems have been studied extensively and intensively since then, Pisinger, (1995). Many theoretical studies of Knapsack problems have been intended and applied to real life problems. Many that were mostly application oriented made researchers and practitioners look for better and faster solutions to cope with vast industrial and financial management problem. The Knapsack problem has been studied for more than a century with earlier work dating as far back as 1897. It is not known how the name Knapsack originated though the problem was referred to as such in early work of mathematician Tobias Dantzig suggesting that the name could have existed in folklore before mathematical problems have been fully defined. (Kellerer et. al 2004)

The Quadratic Knapsack problem was first introduced by Gallo Hammer and Simeone in 1960. A 1998 study of the Stony Brook University algorithms repository showed that out of seventy five (75) algorithmic problems, the Knapsack problem was the 18th most popular and 4th most needed after Kid tree, Suffix trees and the bin parking problem.

The basic concept of all of the Knapsack problems involve the selection of some items, each with profit and weight value, to be packed into one or more Knapsacks with capacities. The item profit ¢ weight w_r as well as the capacity c of the Knapsack are all assumed to be positive integers. Several instances of Knapsack problems, despite their worst-case complexity, may have efficient solution via heuristic method, with acceptable computational time. The heuristics takes advantage of the well defined structure inherent in these problems. Dantzing (1937) was the first to order times according to their profit-to-weight ratio, and then find a solution or the continuous 0-1 Knapsack problem. $F_i > A > \ldots > A$

According to Dzantzig. (1963), the ordering of the items according to this ratio can be done in 0log7, time. He emphasized that the continuous 0-1 Knapsack problem has its constraints on n} e {0, 1…mj related to 0<n <m. A greedily algorithm is then applied on the project-to-weight ratio to assign items to Knapsack starting with the largest until we reach the first item that cannot be assigned. The first unassigned time is termed the Wa and zfem 6 (Ob = min {1: w >c) resulting in an initial feasible solution. The optional solution can then be selected of all items; < b plus the residual of the Knapsack capacity which can be represented by a fraction of item b. this procedure is utilized frequently for various type of Knapsack problems.

Knapsack problem can also be solved using reduction algorithms, (Martello and Toth, 2006) Efficient ones have also been developed which consist of fixing several decision variables at the optional values before the problem is solved. This procedure decreases the decision space thereby resulting in efficient computations. Martello and Torth, (2000) developed the branch-and-bound algorithm which requires the solution of a 0-1 Knapsack problem every time a lower or upper bound is found, for the multiple Knapsack problems.

Munapo, (2006) presented an approach that enhances the performance of the branch and bound algorithm for the Knapsack model. This is achieved by generating and adding new objective function and constraints to Knapsack model which is single constrained. The branch and bound algorithm is then applied and the total numbers of sub-problems are reduced. Majority of algorithms for solving Knapsack problem typically, use implicit enumeration approaches. Different bounds base on the remaining capacity of the knapsack and items not yet included at certain iterations have been proposed for use in these algorithms. Similar methods may be used for a nested Knapsack problem as long as there is an established procedure for testing whether an item inserted into a Knapsack at one stage can also be inserted at the following stages. Given n different items and a Knapsack of capacity, (Caceres and Nishibe, 1998) algorithm solve the 0 – 1 Knapsack problem using 0(nWp) local computation time with O(p) communication rounds. Using dynamic programming, their algorithm solved locally pieces of the Knapsack problem. The algorithm was implemented in a Beowulf and the obtained time showed good speed-up and scalability.(Robert, 1978).

Silva et. al, (2008) dealt with the problem of inaccuracy of the solutions generated by meta-heuristic approaches for combinatorial optimization bi-criteria {0, 1}-knapsack problems.

Huttler and Mastrolilli, (2006) addressed the classical knapsack problem and a variant in which an upper bound is imposed on the number of items that can be selected. The authors also maintained that appropriate combinations of rounding techniques yield novel and more powerful ways of rounding. Moreover, they presented a linear-storage polynomial time approximation scheme (PTAS) and a fully polynomial time approximation scheme (FPTAS) that compute an approximate solution, of any fixed accuracy, in linear time. These linear complexity bounds give a substantial improvement of the best previously known polynomial bounds.

Hybrid approach which combines systematic and heuristic searches was proposed to reduce that inaccuracy in the context of a scatter search method. The components of this method were used to determine regions in the decision space to be systematically searched. Comparisons with small and medium size instances solved by exact methods were presented. Large size instances were also considered and the quality of the approximation was evaluated by taking into account the proximity to the upper frontier, devised by the linear relaxation, and the diversity of the solutions. Comparisons with other two well-known meta-heuristics were also performed. The results showed the effectiveness of the proposed approach for both small/medium and large size instances.

A critical event tabu search method which navigates both sides of the feasibility boundary has shown effectiveness in solving the multidimensional knapsack problem. In their paper, they applied the method to the multidimensional knapsack problem with generalized upper bound constraints. Li and

(Curry, 2005) demonstrated the merits of using surrogate constraint information versus a Lagrangian relaxation scheme as choice rules for the problem class. A constraint normalization method was presented to strengthen the surrogate constraint information and improve the computational results. The advantages of intensifying the search at critical solutions were also demonstrated.

Hanafi and freville, (1998) described a new approach to Tabu Search (TS) based on strategic oscillation and surrogate constraint information that provides a balance between intensification.

Heuristic algorithm like Tabu Search and Genetic algorithm have also appeared in recent times for the solution of Knapsack problems. (Chu et al. 1998), proposed a genetic algorithm for the multidimensional Knapsack problem.

Florios et al., (2009) solved instances of the multi-objective multi-constraint (or multi-dimensional) knapsack problem (MOMCKP) from the literature, with three objective functions and three constraints. They used exact as well as approximate algorithms. The exact algorithm is a properly modified version of the multi-criteria branch and bound (MCBB) algorithm, which is further customized by suitable heuristics. Three branching heuristics and a more general purpose composite branching and construction heuristic were devised. Furthermore, the same problems are solved using standard multi-objective evolutionary algorithms (MOEA), namely, the SPEA-2 and the NSGA-II. The results from the exact case show that the branching heuristics greatly improve the performance of the MCBB algorithm, which becomes faster than the adaptive ε -constraint. Regarding the performance of the MOEA algorithms in the specific problems, SPEA-2 outperforms NSGA-II in the degree of approximation of the Pareto front, as measured by the coverage metric (especially for the largest instance).

While the 1980s focused on the solution of large sized “easy” knapsack problems (KPs), the 1990s brought several new algorithms, which were able to solve “hard” large sized instances.

Martello et al., (2000) gave an overview of the recent techniques for solving hard KPs, with special emphasis on the addition of cardinality constraints, dynamic programming, and rudimentary divisibility. Computational results, comparing all recent algorithms, were presented.

Another critical issue in almost all sectors is the allocation of resources among different activities which has lead to a multitude of research appears on this topic.

Work on non-linear Knapsack problems (Zoltners and Sinha 1975), provided a review of a conceptual framework for sealed resources allocation modeling. They developed general model for sales resource allocation which simultaneously account for multiple sales resources, multiple items period and carry over several actual applications of the model in practice, which illustrates the practical value of their integer programming models.

The problem of resource allocation among different activities such as allocating a marketing budget among sales territories is analyzed by Luss and Gupta (1980). The authors assumed that the return function for each territory uses different parameters and derives single-pass algorithms for different concave pay off functions (based on the Karush-Kuhn-Tuncker (KKT) condition in order to maximize total returns for a given amount of effort.

Carlo Vercellis (1994) described a Lagrangean decomposition technique for solving multi-project planning problems with resource constraints and alternative modes of performing each activity in the projects. The decomposition can be useful in several ways: from one side, it provided bounds on the optimum, so that the quality of approximate solutions can be evaluated. Furthermore, in the context of branch-and-bound algorithms, it can be used for more effective fathoming of the tree nodes. Finally, in the modeling perspective, the Lagrangean optimal multipliers can provide insights to project managers as prices for assigning the resources to different projects.

Important classes of combinational optimization problems are the Multidimensional 0-1 Knapsacks and various heuristic and exact methods have been devised to solve them. Among these, Genetic Algorithms have emerged as a powerful new search paradigms. Hoff et.al, (1985) showed how a proper selection of parameters and search mechanisms lead to an implementation of Genetic Algorithms that yields high quality solutions. The methods were tested on a portfolio of 0/1 multidimensional knapsack problems from literature and a minimum of domain-specific knowledge is used to guide the search process. The quality of the produced results rivals and in some cases surpasses the best solutions obtained by special-purpose methods that have been created to exploit the special structure of these problems

Fubin and Ru (2002) presented a Simulated Annealing (SA) algorithm for the o/1 multidimensional knapsack problem. Problem-specific knowledge is incorporated in the algorithm description and evaluation of parameters. In order to look into the performance of finite-time implementation of SA Computational results showed that SA performs much better than a genetic algorithm in term of solution time, whilst requiring only a modest loss of solution quality.

The Knapsack Sharing Problem (KSP) is an NP-Hard combinatorial optimization problem, admitted in numerous real world applications. In the KSP, we have a knapsack of capacity c and a set of n objects, namely {\cal N}, where each object j, $j = 1\ldots n$, is associated with a profit pj and a weight wj. The set of objects {\cal N} is composed of m different classes of objects. The aim is to determine a subset of objects to be included in the knapsack that realizes a maximum value over all classes.

Hifi et al., (2002) solved the Knapsack Sharing Problem (KSP) using an approximate solution method on tabu search. First, they described a simple local search in which a depth parameter and a tabu list were used. Next, they enhanced the algorithm by introducing some intensifying strategies. The two versions of the algorithm yielded satisfactory result within reasonable computational time. Extensive computational testing on problem instances taken from the literature showed the effectiveness of the proposed approach.

Standard heuristics in operations research (such as greedy, tabu search and simulated annealing) work on improving a single current solution. Population heuristics use a number of current solutions and combine them together to generate new solutions. Heuristic algorithms encountered in the literature that can generically be classified as population heuristics include; genetic algorithms, hybrid genetic algorithms, memetic algorithms, scatter-search algorithms and bionomic algorithms.

Beasley (2002) discussed the basic features of population heuristics and provided practical advice about their effective use for solving operation research problems including knapsack problems.

The MULTKNAP algorithm, which is based on the MTM framework on Martello and Torh, is the first algorithm capable of solving large size then cases of up to n = 100,000 with data range of as much as R = 10,000. MULTKNAP uses specialized algorithm to derive both lower and upper bounds as well as solve the subset-sum problem. It has been demonstrated that despite the unsuitability of multiple Knapsack problem in dynamic programming, dynamic programming algorithms can be used to provide the needed solution Pisinger, (2005).

(Bazgan et. al., 2007) presented an approach, based on dynamic programming for solving the O-1 multi objective Knapsack problem. The main idea of the approach relies on the use of several complementary dominance relations to discard partial solution that cannot lead to new non-dominated criterion vectors. This helped them to obtain an efficient method, that out performs the existing methods both in terms of CPU time and size of solved instances. Extensive numerical experiments on various types of instances were not only reported, but comparison with other exact methods was also performed.

Shang-Hua, (1991) considered the design of the time-efficient and processor efficient parallel algorithm for the integral Knapsack problem. A parallel integral Knapsack algorithm is presented, which is adaptive to all parameters, especially to the maximum size of items. The parallel complexity of another important packing, the integral exactly-packing problem is also considered. An optimal $0(\log n \log m)$ time, parallel in integral exactly packing algorithm is given. Since the partition problem has a constant time, constant processor reduction to the exactly-packing problem, their parallel integral exactly-packing algorithm can be used for job scheduling task, partition and many other important practical problems. Moreover, the methods and techniques used in their paper can be used for developing processor-efficient and time efficient parallel algorithms for many other problems. Using the new parallel integral Knapsack algorithm, the previously known parallel approximation schemes for the 0-1 Knapsack problem and the bin packing problem are improved upon significantly.

2.2 BOUNDED KNAPSACK PROBLEM

The Bounded Knapsack problem (BKP) is a generalization of the 0-1 Knapsack problem where a bounded amount of each item type is available. Currently the most efficient algorithm for (BKP) transforms the data instantly to an equivalent 0 – 1 Knapsack Problem, which is solved efficiently through a specialized algorithm.

Pisinger, (1995) proposed a specialized algorithm that solves an expanding core problem through dynamic programming such that the number of enumerated item types is minimal. Sorting and reduction is done by need, resulting in very little effort for the preprocessing. Compared to other algorithms for BKP, the presented algorithm uses tighter reductions and enumerates considerably less items types. Computation experiments are presented, showing that the presented algorithm outperforms all previously published algorithms for BKP.

Another approximate algorithm has been proposed by Moser et al., (1983) for the solution of the multi choice multidimensional Knapsack problem (MMKP). The algorithm uses the concept graceful degradation form the most valuable item based on Lagrange multipliers.

Khan et al., (2000) proposed an algorithm based mainly on the aggregate resources already used by Toyoda, (1996) for solving the MDKP. The method works as follows; (i) starts with finding an initial feasible solution (ii) use Toyoda's concept of aggregate resources for selecting terms to pick and (iii) use iterative improvement of the solution by exchange of picked items.

2.3 GREEDY ALGORITHM

A greedy algorithm was proposed by Martello and Toth, (2006) for approximately solving the Knapsack problem. For the classical binary Knapsack problem, the approach is composed of two stages;

(i) sort the items in decreasing order of value-weight ratio and

(ii) pick a s many items as possible from the left of the ordered list until the resource constraint is violate.

By using the same principle for the MDKP, Toyoda used the aggregate resources consumption. This solution needs iterative picking until the resource constraint is violated.

Rinnooy et al., (1993) proposed a class of generalized greedy algorithm which is for the solution of the multi-Knapsack problem. Items are selected according to decreasing ratio of their profit and a weighted sum of their requirement coefficient. The solution obtained depended on the choice of weights. A geometrical presentation of the method was given and the relation to the dual of the linear programming relaxation of multi-Knapsack is exploited. They investigated the complexity of computing a set of weights that gives the maximum greedy solution value. Finally the heuristics were subjected to a worst-case and probabilistic performance analysis.

2.4 S-Curve

The literature on knapsack problems in which the objective function is non-convex and non-concave is somewhat limited. Ginsberg, (1974) was the first to consider a Knapsack problem with S-curve return functions, which he referred to as nicely convex-Concave production functions. He characterized structural properties of optimal solutions assuming differentiability of the return function and predominantly assuming identical return functions. Lodish, (1971) considered a non linear non-convex Knapsack problem in sales force planning context in which the response function is defined at discrete levels of sales force time investment. He approximated this problem using the upper piecewise linear concave envelope of each function and provided a greedy algorithm for solving this problem. (This greedy algorithm provides an optimal solution for certain discrete Knapsack sizes, but not for an arbitrary Knapsack size.) Freeland and Weinberg, (1980) addressed the continuous version of this problem and proposed solving the approximation obtained by using the upper envelope of each continuous return function.

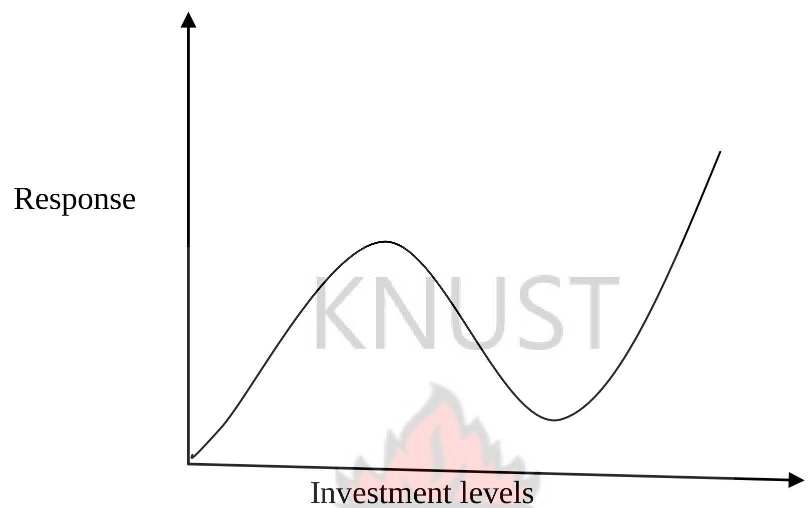


Figure 2.1 an S-curve function

2.5 ANT COLONY

Ant Colony optimization algorithm is a novel simulated evolutionary algorithm, which provides a new method for complicated combinatorial optimization problems. Shuang et al, (2006) used the algorithm for solving the Knapsack problem. It was improved in selection strategy and information modification, so that it cannot easily run into the local optimum and can converge at the global optimum. The experiment showed the robustness and the potential power of this kind of meta-heuristic algorithm.

2.6 FUZZY KNAPSACK PROBLEM

Lin and Yao, (2001) investigated a Knapsack problem in which all of the weight coefficients are fuzzy numbers. The work was based on the assumption that each weight coefficient is imprecise due to the use of decimal truncation or rough estimation of the coefficient by the decision maker. To deal with this kind of imprecise data, fuzzy sets provide a powerful tool to model and solve this problem. Their work was intended to extinct the original Knapsack problem into a more generalized problem that would be useful in practical situations. As a result, their study showed that the fuzzy Knapsack problem is an extension of the crisp Knapsack problem in a special case of the fuzzy knapsack problem.

Elhedlic (2005) considered a class of nonlinear Knapsack problems with applications in service systems design and facility location problems with congestion. The author provided two linearization and their respective solution approaches. The first is solved directly using a commercial solver. The second is a piecewise linearization that is solved by cutting plane Method.

Caprara and Monaci (2004) addressed the two dimensional Knapsack problem (2kp) aimed at packing a maximum-profit subset of rectangle selected from a given set into another rectangle. They considered the natural relaxation of 2KP given by the one-dimensional KP with item weights equal to the rectangle areas, proving the worst-case performance of the associated upper bound, and presented and compared computationally four exact algorithms based on the above relaxation, showing their effectiveness.

Yield management is an important issue for cooperate organization and television advertising in particular. The major part of the research is revenue management focuses on the airline or hotel industry. The TV advertising case has some specifications, where the most important is the decomposition of the offer into a lot of small TV breaks. Martin, (2003) proposed genetic solution based on simulations and approximate dynamical programming.

The data association problem consists of associating piece of information emanating from different sources in order to obtain better description of the study. This problem arises; in particular, when considering several sensors, we aim at associating the measures corresponding to a same target. This problem widely studied in the literature, is often stated as a multidimensional assignment problem where a stated criterion is optimized. While this approach seems satisfactory in simple situations, the risk of confusing targets is relatively low. It is much more difficult to get correct description in denser situations.

Hugot et al., (2006) proposed to address this criteria framework using a second complementary criterion base on the identification of the targets. Due to the specificities of the problem, simple and efficient approach can be used to generate non-dominated solution. Moreover, they showed that the accuracy of the proposed solution is greatly increased when considering a second criterion. A bi-criteria interactive procedure is also introduced to assist an operator in solving conflicting situations.

2.7 MULTI KNAPSACK PROBLEM

According to Chekuri and Hanna (2005) the multiple Knapsack problems (MKP) is a natural and well-know generalization of the single Knapsack and is defined as follows. Supposing a set m items and n bins (Knapsacks) are given such that each item i has a profit p(i) and a size s(i) and each bin j has a capacity C(i).The goal is to find a subset of items of maximum profit such that they have a feasible packing in the bins. MKP is a special case of the generalized assignment problem (GAP) where the profit and a size of an item can vary based on specific bin that it is assigned to GAPS is APX-hard and a 2-approximation, for it is implicit in work of Shmoy and Tardos, (1990). This was also the best known approximation for MKP. The main result of shmoys and Tardos, (1994) is a polynomial time approximation scheme (PTAS) for MKP. Apart from its inherent theoretical interest as a common generalization of the well-studied knapsack and bin packing problems it appears to be the strongest special case of GAP that is not, APX-hard. They substantiated them by showing that slight generalizations of MKP are APX-hard.

Thus their results helped to demarcate the boundary at which instances of GAP become APX-hard. An interesting aspect of this approach is a PTAS-Preserving reduction from an arbitrary instance of MKP to an instance with MKP to an instance with 0(log n) distinct sizes and profit.

The Knapsack sharing problem (KSP) is formulated as an extension to the ordinary knapsack problem. The KSP is NP-hard.

Yamada et al., (2008) presented a branch–and-bound algorithm and a binary search algorithm to solve this problem to optimality. These algorithms are implemented and computational experiments are curried out to analyze the behavior of the developed algorithms. As a result, they found that the binary search algorithm solved KSPs with up to 20,000 variables in less than a minute in their computing environment

Probability and stochastic algorithms have been used to solve many hard optimization problems since they can provide solution to problems where often standard algorithms have failed. These algorithms basically search through a space of potential solution using randomness as a major factor to make decision. In their search, the knapsack problem (optimization problem) can be solved using a genetic algorithm approach. Subsequently, comparism is made with greedy method heuristic algorithm. The knapsack problem is recognized to be NP hard. Genetic algorithms are among search procedures based on natural selection and natural genetics. They randomly create an initial population of individuals, then, they use genetic operators to yield new offspring. In their search, a genetic algorithm is used to solve the 0-1 knapsack problem. Special consideration is given to the penalty function where constant and self–adaptive penalty functions are adopted (Zohier, 2010).

Lin and Wei, (2008) proposed an efficient linear search algorithm for resolving the 0/1-knapsack problem. A net profit criterion is included in the linear search algorithm to generate a rescheduled candidate set. Four hard cases presented by Yang, (1990) were tested and compared with the revised approach. Our results demonstrate that the approach proposed herein outperforms previous works in terms of producing a small candidate set while retaining most of the information on optimal

The transposition mechanism, widely studied in previous publications, showed that when used instead of standard crossover operators allows the genetic algorithm to achieve better solutions. Nevertheless, all the studies made concerning this mechanism always focused the domain of function optimization.

Simoes and Costa (2001) presented an empirical study that compares the performances of the transposition A -based Genetic Algorithm (GA) and the classical GA for solving the 0/1 knapsack problem. The obtained results showed that, just like in the domain of the function optimization, transposition is always superior to crossover.

Method of determining allocations in a business operation to maximize profit includes: collecting profit data for a plurality of classes in the business operation, where each class includes an allocation having a cost function and each allocation belongs to the group consisting of physical allocations and economic allocations; determining profit functions for the allocations from the profit data; formulating a Multiple Choice Knapsack Problem to maximize profit from the profit functions, the cost functions, and a cost constraint; and solving the Multiple choice Knapsack Problem to determine values for the allocations.(European Patent Application EP1350203)

Fontanari (1995) investigated the dependence of the multi-Knapsack objective function on the multi-Knapsack capacities and on the capacity constraints P, in the case when all

N objects are assigned the same profit value and the weights are uniformly distributed over the unit interval. A rigorous upper bound to the optimal profit is obtained employing the annealed relaxation method. The analysis is restricted to the regime where N goes to infinity and P remains finite.

Managers in retail industry make important decisions up assortments planning, product pricing and product promotion. While product assortment is a strategic decision taken over a long term planning period, the latter are both strategic and tactical. They can be used in day-to-day marketing decision to dynamically adjust to demand variations. Within the food retail industry,

The necessity, Frequency, and Complexity of pricing and promotion decisions are further magnified by perish ability of food products. There is a strong need by retail managers for 'soft' marketing tools, which would dynamically allow them to improve sales and revenue, yet not altering product prices. For, dynamic pricing models may prescribe to change prices too often or in an 'unsystematic' fashion which contradicts discrete time decision making, implementation costs and retail brand image strategy. In addition, the price reduction must usually be done over all units of the products, thus losing possible profit from customers willing to pay the original, higher price. Furthermore, dynamic pricing results in a tradeoff between markdowns and stock outs since markdowns may damage producers, while stock out may damage retailers, Jacko (80)

Transportation programming, a process of selecting projects for funding given budget and other constraints, is becoming more complex. Zhong and Young (2009) described the use of an integer programming tool, Multiple Choice Knapsack Problem (MCKP), to provide optimal solutions to transportation programming problems in cases where alternative versions of projects are under consideration. Optimization methods for use in the transportation programming process were compared and then the process of building and solving the optimization problems discussed. The concepts about the use of MCKP were presented and a real-world transportation programming example at various budget levels were provided. They illustrated how the use of MCKP addresses the modern complexities and provides timely solutions in transportation programming practice.

The knapsack container loading problem is the problem of loading a subset of rectangular boxes into a rectangular container of fixed dimensions such that the volume of the packed boxes is maximized. A new heuristic based on the wall-building approach was proposed earlier. That heuristic divides the problem into a number of layers and the packing of layers is done using a randomized heuristic. Juraitis et al., (2006) focused on ways to find proportions of the mixture of heuristics which would lead to better performance of the algorithm. New results were compared with earlier research and some other constructive heuristics.

The performance of the corresponding algorithms was experimentally compared for homogeneous and heterogeneous instances. Proposed improvements allow achieving better filling ratio without increasing the computational complexity of the algorithm

SUMMARY

In this chapter, we put forward a review of some literature on the knapsack algorithms. The next chapter is devoted for the research methodology of the study.

CHAPTER THREE

3.1 INTRODUCTION

The staging and broadcasting of exiting events and programmes all over the world on TV have not made the medium attractive and well patronized, but also the establishment of the stations competitive. The use of sophisticated equipments and or gadgets, staff recruitment and motivation therefore, are necessities which require huge funding. Ghana in particular, the number of TV stations has shot up from one in 1965 to over twenty (20) in 2012. This has really called for the need to adopt careful and optimal parking skills to enhance the achievement of the following among others;

(i) Absolute customer confidence, good will and trust.

(ii) optimum use of airtime and avoidance of pile up commercials and programmes

(iii) increase production and maximization of profit

(iv) increase the station's growth rate

3.2 KNAPSACK ALGORITHM

The Knapsack problem is a classic problem with a single constraint. The most common formation of the problem is the 0-1 Knapsack problem which restricts the number xi of copies of each kind of item to zero or one. Mathematically, the 0-1 knapsack problem

can be formulated as Maximize $\sum_{i=1}^{n} v_i x_i$ 3.1

Subject to $\sum_{i=1}^{n} w_i x_i \le W \quad x_i \in \{0,1\}$ 3.2

A similar dynamic programming solution for the 0-1 knapsack problem also runs in pseudo-polynomial time. As above assume w_1, w_2, ..., w_n, W are strictly positive integers. We defined m [i, w] to be the maximum value that can be attained with weight less than or equal to w using items up to i. We can define m [I, w] recursively as follows;

$m[0, w] = 0$

$m[i, 0] = 0$

$m[i, w] = m[i = 1, w]$, if $w_i > w$ (the new item is more than the current weight limit)

. $m[i, w] = \max[i = 1, w], m([i-1, w - w_i] + v_i)\ if, w_i \le w$

The solution can then be found by calculating $m[n, w]$. To do this efficiently, we can use table to store previous computations. This solution will therefore run in $0(nW)$ space. Additionally, if we use only one dimensional array of $m[w]$ to store the current optional value and pass over this array (i+1) times rewriting from $m[w]$ every time we get the same result for only $0[w]$ space.

Another algorithm for 0-1 Knapsack discovered in 1974 and sometimes called “meet-in-the-middle” due to parallels to a similarly-named algorithm in Cryptography, is exponential in the number of different items but may be preferable to the Dynamic Programming (DP) algorithm where ‘W’ is large compared to ‘n’. In particular, if the w_i are non negative but not integers. We could still use the dynamic programming algorithm by scaling and rounding (ie using fixed point algorithm) but if the problem requires d fractional digit of precision to arrive at the correct answer. W will need to be scaled by 10^d and the DP algorithm will require $0\left(W^*10^d\right)$ space and $0\left(nW^*10^d\right)$ times.

The meet-in-the-middle algorithm is as follows;

(i) Partition the set {1…n} into two sets A and B of approximately equal size.

(ii) Compute the weights and values of all subsets of each set.

(iii) For each subset of A, find the "the best matching" of B, i.e. the subset of B of greatest value such that the combined weight is less than W. Keep track of the greatest combined value seen so far. The algorithm takes $0(2^{n/2})$ space and efficient implementations of step (iii) (for instance, sorting the subset of B by weight, discarding subsets of B which weigh more than other subsets of B of greater or equal value, and using binary search to find the best match) result in a runtime of $0(n^*2^{n/2})$. As in the meet- in- the- middle Cryptography this improves on the $0(n^* 2^n)$ runtime of naive brute force approach examining all subsets of (1…n) at the cost of using exponential rather than constant space.

3.3 UNBOUNDED KNAPSACK PROBLEM (UPK)

The UKP places no upper bound on the number of copies of each kind of item. Of particular interest is the special case of the problem with the properties.

(i) It is a decision problem

(ii) It is a 0-1 problem

(iii) For each kind of weight equals the value ($w_i = v_i$)

The unbounded Knapsack generally seeks to answer the following questions; given a set of non negative figures, does any subset of it add up to exactly W? Or if negative weights are allowed and W is chosen to be zero, does any non empty subset add up to exactly 0? This special case is called subset sum problem and can be formulated as below.

$$P_i = w_j, (j = 1...n) \tag{3.3}$$

$$\text{Maximize } \sum_{j=1}^{n} (w_j \mathrm{x} j) \text{ i.e } w_1 x_1 + w_2 x_2 + ... w_n x_n \tag{3.4}$$

$$subject \text{ to } \sum_{j=1}^{n} (w_j x_j) \leq c \text{ i.e } w_1 x_1 + w_2 x_2 + ... + w_n x_n \quad x_j = 0 \text{ or } 1, \text{ j=1...n} \tag{3.5}$$

If all weights ($W_{1,}$ W_2 … W_n) are non negative integers, the Knapsack problem can be solved in pseudo-polynomial time using dynamic programming. The following describes dynamic programming solution for the unbounded Knapsack problem. To make things easier, assume all weights are strictly positive (W_i > 0). We wish to maximize total value subject to the constraint that total is less than or equal to W. Then for each $w \leq W$, defined $m[w]$ to be the maximum value that can be attained with total weight less than or equal to W. $m[w]$ then is the solution to the problem. Observe that $m[w]$ has the following properties.

$m[0] = 0$ (the sum of the zero items, i.e. the sum of the empty set)

$m[w] =$ Max$(v_i + m[w - w_i]), \quad w_i < w$

Where' v' is the value of the i^{th} kind of item. Here, the maximum of the empty sets is taken to be zero. Tabulating the results from $m[0]$ up through $m[w]$ gives the solution. Since the calculation of each $m[w]$ involves examining n items, and there are W values of $m[w]$ to calculate, the running time of dynamic programming solution $0(nW)$ dividing $w_1, w_2 ... w_n$, by their greatest common divisor is an obvious way to improve running the time.

The $0(nW)$ complexity does not contradict the fact that the Knapsack problem is NP-complete, since W unlike n, is not polynomial in the length of the imput to the problem. The length of the W input to the problem is proportional to the number of bits in W, Log W, not to W itself.

3.4 THE DOMINANCE PROGRAMMING APPROACH

It is applicable to Knapsack if certain integrality conditions of the co efficient hold

$$Max \frac{\sum_{j=1}^{m} p_j w_j}{\sum_{j=1}^{m} a_j w_j} \leq Z \quad , \quad w_1 ... w_m \in \{(0,1)^m\} \qquad 3.6$$

The recursive equation at the m^{th} stage is $P_m(z) = P_{m-1}(\text{z}) \;\; 0 \leq z \leq a_m$

$$Max\{p_{m-1}(z), p_{m-1}(z - a_m) + p_m\}, \; a_m \leq z \leq b \qquad 3.7$$

With initial condition

$$P(z) = 0, \quad o \leq z \leq a_1 \qquad 3.8$$

For a_j, j≥1, the dynamic programming algorithm constructs a table of dimension $N*(b+1)$ and calculates the entries $P_m(z),\ m=1...N,\ z=0...b$ in a bottom-up function. An optimal solution can be found by backtracking through the table once the optimal value $p_{N(b)}$ is obtained.

3.5 GREEDY APPROXIMATION ALGORITHM

George Dantzig proposed a greedy approximation algorithm to solve the unbounded Knapsack problem. His version sort the items in decreasing order of value per unit of weight ($\frac{v_i}{w_i}$), it then proceeded to insert them into the sack, starting with as many copies as possible, the first kind of items until there is no longer space in the sack for more. Provided that there is an unlimited supply of each kind of item, if M is the maximum value of items that fit into the sack, then the greedy algorithm is guaranteed to achieve at least a value of $\frac{m}{2}$. However, for bounded problems, where the supply of each kind of item is limited, the algorithm may be far from optimal.

3.6 DOMINANCE RELATIONS IN THE UKP

Solving the unbounded Knapsack problem can be made easier by throwing away items which will never be needed. For a given item; i, suppose we could find a set of items j such that their total weights value is less than weight of i and their total value is greater than the value of i, then the i cannot appear in the optimal solution because we could always improve upon any potential solution containing i by replacing i with the set j. Therefore we could disregard the i th item altogether. In such cases J is said to dominate (this does not apply to bounded Knapsack problems since we may have already used up the item in j.)

Finding dominance relations allows us to significantly reduce the size of the search space. There are several different types of dominance relations which satisfy an inequality of the form

$$\sum_{j \in J} w_j x_j \le \alpha w_i \text{and} \sum_{j \in J} v_j x_j \ge \alpha v_i \text{ for some } x \in z_+^n$$

The i^{th} item collectively dominate by j, written as i << J. If the total weight of some combination of items in j is less than w_i and their total value is greater than v_i

3.7 COLLECTIVE DOMINANCE

Formally, $\sum_{j \in J} w_j x_j \le w_i$ and $\sum_{j \in J} v_j x_j \ge v_i$ for some $x \in z_+^n \Rightarrow \alpha = 1$

Verifying this dominance is computationally hard, so it can only be used with the dynamic programming approach. In fact, this is equivalent to solving Knapsack decision problems where $2v = v_i, w = w_i$ and the items are restricted to J.

3.8 THRESHOLD DOMINANCE

The i^{th} tem is threshold dominated by J written as, $i \succ j$, if some number of copies of i are dominated by J

Formally, $\sum_{j\in J} w_i x_i \leq \alpha w_i$ and $\sum_{j\in} v_j x_j\, j$ for some $x \in z_+^n$ and $\alpha \geq 1$.

This is generalization of collective dominance. The smallest such $\propto$ defines the threshold of items i written as $t_i = (\alpha - 1) w_i$. In this case, the optimal solution could contain at most $\alpha - 1$ copies of i.

3.9 MODULAR DOMINANCE

Let b be the item i.e. $\frac{v_b}{w_b} \geq \frac{v_i}{w_i}$ for all i. This is the item with greatest density of value

.The i^{th}

item is modularly dominated by single item j, written as $i \succ \equiv j$,if i is dominated by j plus several copies of b.

Formally $w_j + t w_b \leq w_i$ and $v_j + t v_b \geq v_i$ i.e $J = \{b_j\}, \alpha = 1,\ b = t,\ j = 1$

3.10.0 MULTIPLE DOMINANCES

The i^{th} item is multiply dominated by a single item $_j$, written as $i \square \; m_j$. If $_i$ is dominated by some number of copies of $_j$, formally, $w_j x_j \leq w_i$ and $v_j x_j \geq v_i$ for some $x_j \in Z_+$ i.e. J={j},∝= 1, $\frac{w_i}{w_j}$. This dominance could be efficiently used during preprocessing because it can be detected relatively easily.

3.10.1 SIMULATED ANNEALING

Simulated annealing is a local search algorithm capable of escaping from local optima. According to Amponsah and Darkwah (2007) the concept of simulated annealing is derived from mechanics in the area of natural science. Annealing is the slow cooling of a metallic material so that at natural temperature conditions, the metal will achieve regularity of alignment of the magnetic direction so as to make the metal stable for use. A piece of metal in its natural state has the magnetic directions of its molecules aligned in a uniform direction. In the preparation of alloys, the metals are heated to a very high temperature where the molecules require higher energy state. The basic structure of the metallic bonds breakdown and the magnetic direction of the molecules are oriented randomly. Simulated annealing is so named because of its analogy to the process of physical annealing with solids in which a crystalline solid is heated and then allowed to cool very slowly until it achieves stable state, i.e. minimum lattice energy state and thus is free from crystal effect. Simulated annealing mimics this type of thermodynamic behavior in searching for global optima for discrete optimization problems (DOP).

In 1983, Kirk Patrick showed how simulated Annealing of metropolis could be used to solve problems in combinational optimization. The following analogy was made;

i (a) Annealing looks for system state at a given temperature and energy.

(b) Optimization looks for feasible solution of the combinational problem

ii (a) Cooling of the metal is to move from one system state to another.

(b) Search procedure (algorithm scheme) tries one solution after another in order to find the optimal solution.

iii (a) Energy function is used to determine the system state and energy.

(b) Objective (cost) function is used to determine a solution and the objective function value.

iv (a) Energy results in evaluation of objective function and the lowest energy state corresponds to stable state.

(b) Costs results in evaluation of objective function and the lowest objective function -value corresponds to optimal solution.

v (a) Temperature controls the system state and energy.

(b) A control parameter is used to control eh solution generated and the objective function value.

Given an optimization problem, we put it in the form Min f(x) such that $\mathcal{X} \epsilon$ S where S is the feasible solution of the problem. Algorithm for solving basic simulated Annealing is indicated below with the indication of the parameter. (i) = solution (system state)$_j$

F(x) = objective function (Energy function)

K= iteration number (time check in cooling process)

r = f(x) – f(x°) (energy change between states x^1 and x^0)

T = Control parameter (Temperature of system)

g(T) = Control parameter function (Temperature function)

$e^{-(r/T)}$ =choice probability function (Boltzmam probability function); It also provides the condition under which a non-improvement solution is not discarded.

Step 1

(i) Select an initial solution $\mathcal{X}^{(0)}$ assign $\mathcal{X}^{(b)} = \mathcal{X}^{(0)}$

(ii) Set K = 0, select an initial temperature (control parameter) $T_K = T_o$ for k = 0, assign $T_b = T_o$

(iii) Select a temperature function $g(T_k)$

Step 2: Choose a solution $x^{(1)}$ in $N(x^{(0)})$ and compute $\delta = f(x^{(1)}) - f(x^{(0)})$

Step 3: If δ = 0 or [δ > 0 and $e^{-\frac{\delta}{T_k}} \geq \theta : \theta \leftarrow U = (0,1)$], accept the new solution $\mathcal{X}^{(1)}$.

Assign $x^{(0)} \leftarrow x^{(1)}$ and keep the new $x^{(0)}$ such that $x^{(0)} = x^{(b)}$, Set $T_b = T_k$

Step 4: If some stopping criteria are identified, stop it.

Step 5: Update the temperature $T_{k+1} = g(T_K) \leq T_K$ and set K=k+1

3.10.2 0- 1 MULTIPLE KNAPSACK

An important generalization of the 0 -1 Knapsack problem is the 0 – 1 Multiple Knapsack problem which arises when n containers of given capacities C_i (i=1,…n) are available. By the introduction of binary variables taking value 1 if item j is inserted into the container i, and 0 (zero) otherwise. The problem can be formulated as follows

$$Max\ z = \sum_{i=1}^{n}\sum_{i=1}^{n} P_{i,j} X_{i,j}$$

Subject to $\sum_{i=1}^{n} w_j x_{i,j} \leq c_i \quad (i = 1 \ldots n)$

$$\sum_{j=1}^{n} x_{i,j} \leq 1 \ \ (j{=}1 \ldots n) \qquad x_{i,j} = 0 \text{ or } 1\ (i = 1 \ldots n,\ j = 1 \ldots n)$$

The generalization arises when the item set is separated into subsets and an additional constraint is imposed that at most one item per subject is called the Multiple-Choice Knapsack problem. The multiple-choice Knapsack problem is defined as in knapsack problem but with additional disjoint multiple choice constraints. The general description of the problem is given as follows;

A Knapsack of limited capacity is provided. Objects to be place in the Knapsack are classified into multiple mutually exclusive classes. Within each class, there are a variety of items. The problem is how to select items from each class so as to minimize the overall cost while the total size of the items does not exceed the limited capacity of the Knapsack. This kind of generalization is NP-hard.

3.10.3 MULTI DIMENSIONAL KNAPSACK PROBLEM (MDKP)

The Multi Dimensional Knapsack Problem (MDKP) is defined as Knapsack with a set of constraints such as weight, size, shape, reliability, etc. The problem can be generalized by assuming that for each integer r, $(1 \leq r \geq n)$ b_r items of profit, p_r items of weight, Wr are available ($b_r \leq \frac{c}{w_r}$), duplicating the Knapsack problem.

3.10.4 METHODS OF SOLVING KNAPSACK PROBLEMS.

As indicated earlier in the review of literature, there are generally two basic methods of solving the 0-1 Knapsack problem (KP). These are the branch and bound and the dynamic programming methods. However, Meta heuristics approach such as Genetic algorithm, Tabu search and simulated annealing have been employed in the case of large scale problems.

The branch-and-bound-method

Branch and Bound is a class of exact algorithm for various optimization problems especially integer programming problems and combinational optimization problems (COP). It separates the solution space into smaller sub problems that can be solved independently (branching). Bounding discards sub problems that cannot contain the optimal solution, thus decreasing the size of the solution space. Branch and Bound was first proposed by Land and Diog in 1960 for solving integer programming. Given the maximum problem;

(i) A Branch and Bound algorithm iteratively partition the solution space. For examples by branching on binary variables-fixing one of the zero (0) in one branch and one (1) in the other branch.

(ii) For each sub-0problem, an upper bound on the objective value is calculated. The upper bound is guaranteed to be greater or equal to the optimal solution for the sub problem

(iii) When a feasible solution (i.e. no fractional variables remaining) is found, all sub problems whose upper bound are lower than this solution's objective value can be discarded.

(iv) The best known feasible solution represents a lower bound for all sub problems, and only sub problems with an upper bound greater than the global lower bound have to be considered.

Discarding a sub problem is called fathoming or pruning. Upper bounds for a sub problem can be obtained by relaxing the sub problem, thus they are often obtained by optimizing the sub problems LP relaxation.

Algorithm for the branch and bound.

Assume that the variables have been ordered such that

$$\frac{p_1}{a_1} \geq \frac{p_2}{a_2} \geq \frac{p_n}{a_n} \qquad 3.9$$

Let p be the maximum index q such that

$$\sum_{j=1}^{n} a_j \leq b$$

The theorem due to Dantzing is shown below which also indicates the solution to the continuous relaxation of KP is

$$w_j = 1 \quad j = 1 \ldots p \qquad 3.10$$

$$w_j = 0 \quad j = p \ldots n \qquad 3.11$$

$$w_{p+1} = b - \sum_{j=1}^{n} \left(\frac{a_j}{a_{p+1}} \right) \qquad 3.12$$

If $K_{j,\, j=1\ldots n}$ are positive integers, then an upper bound of the optimal value of KP is given

by

$$UB = \sum_{j=i}^{p} K_j + [(b - \sum_{j=1}^{p} a_j) K_p + \frac{1}{a_p} + i]$$

3.13

$$UB = \sum_{j=1}^{n} (p_j) + [(b - \sum_{j=1}^{n} a_j) \frac{K_{p+1}}{a_{p+1}}] \qquad 3.14$$

The following method of the branch-and-bound can also be used to determine the upper bound by using the depth-first algorithm

The branch-and-bound method for the knapsack problem

Step 1: Initialization

$$K_{N+1} = 0,\ a_{N+1} = \infty,\ f_{opt} = f \qquad 3.15$$

$$W_{opt} = (0\ldots0)^T$$

Step II (Test heuristic). If $a_i \le w$ find the largest p such that

$$\sum_{j=1}^{p} a_j \le w, \qquad 3.16$$

Set Z $=\sum_{j=1}^{p} k_j + \frac{(w-\sum_{j=1}^{p} a_j)k_{p+1}}{a_{p+1}}$,if $a_j > w,$ set $p = j-1$ and $z = \frac{w_{kp}}{a_p}$ 3.17

If $f_{opt} \geq z_f^+$, go to step IV

Step III (New feasible solution) If $a_i \leq w$ and $i \leq N, set\ w = w - a_i, f + k_i \quad w_i = 1, i = i+1$

Repeat Step III; otherwise, if $i \leq N, set\ w = 0,\ i = i+1,$ if $i = N$ go to Step II.

If i = N repeat Step III. If i > N, go to step IV

Step IV (updating incumbent).

$If\ f_{opt} < f, set\ f_{opt} = f,\ w_{opt} = w$ set $i = N,$ if w_N =1,set w = w+a_N ,

$f = f - k_N, w_n = 0$.

Step V (Backtracking). Find the largest $b < 1$ such that $w_b = 1$. If there is no such a ‘b’

stop and take the current w_{opt} as the optimal solution. Otherwise, se

$w = w + a_b,\ f = f - k_p, w_b = 0, k+1$ and go to step 2

Solving knapsack problem with heuristic scheme

The Heuristic scheme according to Amponsah and Darkwah (2007), may also be used to solve the knapsack problem apart from Branch and Bound method by the following procedure;

Step 1 Input the vector weight (w_j) and item value (c_j)

Step 2 Input random initial solution $S_0 \in \{0,1\}^n$ and check for feasibility of S_0 by using the equation,

$$\sum_{i=1}^{n} W_i \mathcal{X}_i \leq b \qquad 3.18$$

If S_0 is not feasible discard it and choose another S_0

Step 3 Find a feasible solution and compute the objective function value $f(S_o)$ by using the

$$objective\ function\ Max \sum_{j=1}^{n} C_j \mathcal{X}_j \qquad 3.19$$

Step 4 Obtain a new solution $S_1 \in \{0,1\}^n$ from S_0 by flip operation and check for feasibility. Continue the flip operation if the S_1 obtained is feasible. Compute the objective function value $f(s_1)$. If $f(S_I) > f(S_0)$ then set $S_1 = S_{0,}$ else retain S_0 and discard S_1.

Step 5 Repeat step 3 for all feasible $S_{i.}$

Further explanations to the above can be expressed as below;

With the assumption that a traveler has a knapsack that has a maximum capacity of ‘b’ items. The traveler has variety of items; 1, 2, 3….n, the items weight w_j and are of value c_j . How many of the items should be placed in the knapsack in order to maximize the total value for the traveler without exceeding b?

The table together with the model below would further give detailed explanations of the knapsack problem given that our $b=12_{kg}$

Item type	Number of items	Weight of item (wj)	Value of item cj
A	2	3	**3**
B	3	2	**7**
C	5	1	**10**
D	4	3	**20**

Let Xj =1, if the item x_j is included and

Xj = 0 if the item x_j is not included

Maximize $Z = c_1x_1 + c_2x_2 + c_3x_3 + \ldots + c_nx_n \quad = \quad \sum_{j=1}^{n} c_jx_j$

Subject to $W_1X_1 + W_2X_2 + W_3X_3 + \ldots + W_nX_n \leq b \quad = \quad \sum_{i=1}^{n} w_ix_i \leq b$

Substituting the values into the model we have;

Maximize Z = $3(x_1 + x_2) + 7(x_3 + x_4 + x_5) + 10(x_6 + x_7 + x_8 + x_9 + x_{10}) + 20(x_{11} + x_{12} + x_{13} + x_{14})$…[k]

Subject to $3(x_1+x_2) + 2(x_3 + x_4 + x_5) + (x_6 + x_7 + x_8 + x_9 + x_{10}) + 3(x_{11} + x_{12} + x_{13} + x_{14})$..[r]

It is emphasized that xj=1, if the item xj is included and xj=0 if the item xj is not included

Data structure for $x=\{0,1\}^n$ implies x= $\{0,1 \mid 1,0,1 \mid 1,1,0,0,1 \mid 0,1,0,1\}$

Assuming S_o = {0,1 | 1,0,1 | 1,1,0,0,1 | 0,1,0,1} is a solution we check its feasibility by substituting it into equation [r]

$S_0 = \{3(1 + 1) + 2(1 + 0 + 1) + (1 +1 + 0 + 0 + 1) + 3(0 + 1 + 0 + 1)\}$

$= 3 + 4 + 3 + 6 + \leq 12$

$16 \quad \leq 12$ [false]

This is false, therefore, S_o is infeasible solution.

The definition for a simple flip operation is to change a zero to a one and vice versa. If we flip the last digit we have

S_1=(1,0 | 1,0,0 | 1,0,0,1,1 | 0,0,1,0)

$S_0 = 3(1+0) + 2(1+0+0) + (1+0+0+1+1) + 3(0+0+1+0) \leq 12$

$3 + 2 + 3 + 3 \leq 12$

$11 \quad \leq 12$ [true]

This implies that S_o is a feasible solution and the objective function corresponding to S_0 is;

$f(S\ ) = 3(1 + 0) + 7(1 + 0 + 0) + 10(1 + 0 + 0 + 1 + 1) + 20(0 + 0 + 1 + 0)$

$= 3 + 7 + 30 + 20$

$= 60$

Continue the procedure (flip) for S_3, S_4… and select among them the one with the highest objective function value for the optimal solution.

CHAPTER FOUR

DATA COLLECTION AND ANALYSIS

4.0 INTRODUCTION

The British government introduced broadcasting in the Gold Coast (now Ghana) in the 1930's and used it as a propaganda tool to secure the loyalty and supporting of the colonies during the Second World War. During the period, radio became an important medium for providing information on the African soldiers fighting on the side of the allies. Due to radio's integrative role, leaders of the newly independent African Countries retained ownership in the hands of the state and continue to use it as a top-down communication channel. According to Prof. P.A.V. Ansah, one achievement of radio in Ghana has been the forging of common sense of national identity. Cantrill and Allport refer to this integrative role of radio when they wrote "When millions of people hear the same subject matter, the same argument and appeal, the same music and humour, when their attention is held in the same way and at the same time and to the same stimuli, it is psychologically inevitable that they should acquire in same degree, common interest, common tastes and common attitudes (cantrill and Allport, 1935).

It is in the light of these that Metro TV, a private television station in Ghana should be supported to provide a good selection measure of the piled up of adverts for an optimal income to help it carry out its role.

Whiles this research focuses on advertisements which are slotted in the programme schedules, there are other sources of income such as playing of musical videos, business news announcements, advertizing cycles, TV programmes air time buying, etc

The spot adverts are categorized into the following, off peak time, Peak time, Prime time and premium time.

The station has different rates for each category above as shown in the table below.

For instance, a 15 seconds spot advert may cost Gh¢190, Gh¢250, Gh¢420 and Gh¢500 for off peak, peak, prime and premium respectively.

4.1 .DATA COLLECTION

Table 4.0 (Categories of spot advertising)

Time slot	Off peak	Peak	Prime	Premium
15 seconds	GH¢190	GH¢250	GH¢420	GH¢500
30 seconds	GH¢340	GH¢500	GH¢720	GH¢850
45 seconds	GH¢460	GH¢650	GH¢1075	GH¢1250
60 seconds	GH¢640	GH¢920	GH¢1365	GH¢1650

Table 4.1 (Categories of tv program airtime buying)

Time slot	Off peak	Peak	Prime	Premium
30 minutes	GH¢2450	GH¢2800	GH¢3350	GH¢4200
60 minutes	GH¢3250	GH¢3800	GH¢6500	GH¢8000

Table 4.2 (Categories of crawler placement)

Duration	Off peak	Peak	Prime	Frequency
30 minutes	GH¢90	GH¢130	GH¢230	3 per program
60 minutes	GH¢150	GH¢220	GH¢320	5 per program
90 minutes	GH¢230	GH¢320	GH¢420	7 per program

Table 4.3 (Cost of adverting cycles)

Period	2weeks	1 month	2 months	3 months
30 seconds slide show	GH¢1850	GH¢3300	GH¢5400	GH¢9500

Table 4.4 (Cost of musical videos)

Period	1 week	1 month	2 month	3 month
3munites once daily	GH¢475	GH¢1600	GH¢3500	GH¢5000

Table 4.5 (list of commercials for off-peak time for a day)

Advert number	*Number of times requested (wi)*	*Cost (ci) GH¢*
M001	*30*	*340*
M002	*15*	*190*
M003	*15*	*190*
M004	45	460
M005	30	340
M006	45	460
M007	60	640
M008	60	640
M008	60	640
M009	15	190
M010	45	460
M012	15	190
M013	30	340
M014	45	460
M015	45	460
M016	60	640
M017	15	190
M018	15	190
M019	60	640
M020	30	340
M021	15	190

Table 4.6 (List of commercials for peak time for a day)

Advert number	Number of times requested	*Cost (ci) GH¢*
P001	60	920
P002	15	250
P003	15	250
P004	45	650
P005	15	250
P006	45	650
P007	60	920
P008	60	920
P009	15	250
P010	45	650
P011	30	500
P012	45	650

P013	60	920
P014	15	250
P015	15	250
P016	30	500
P017	30	500
P018	15	250

Table 4.7 (List of commercials for prime time for a day)

Company name	Duration of advert requested	*Cost (ci) GH¢*
Q001	45	1075
Q002	30	720
Q003	30	720
Q004	15	420
Q005	15	420
Q006	60	1365
Q007	15	420
Q008	60	1365
Q009	60	1365
Q010	45	1075
Q011	30	720
Q012	15	420
Q013	15	420
Q014	45	1075
Q015	45	1075
Q016	60	1365
Q017	45	1075
Q018	60	1365
Q019	15	420
Q020	30	720
Q021	30	720
Q022	15	420
Q023	60	1365

Table 4.8 (List of commercials for premium time for a day)

Company name	Duration of advert requested	*Cost (ci) GH¢*
R001	45	1250
R002	45	1250
R003	60	1650
R004	15	500
R005	45	1250
R006	15	500
R007	60	1650
R008	60	1650
R009	60	1650
R010	30	850
R011	15	850
R012	15	500
R013	30	500
R014	30	500
R015	15	500
R016	30	850

4.2 DATA ANALYSIS

Computer software ‘ADVERTMaster’ developed in Visual Basic Dot Net was used to analyze the data collected for Metro TV using a simple flip heuristic scheme algorithm.

4.3 FEATURES OF THE SOFTWARE

The interface below displays features of the software. It takes data input from csv-files entered in excel or data may be entered manually. This makes the software user friendly.

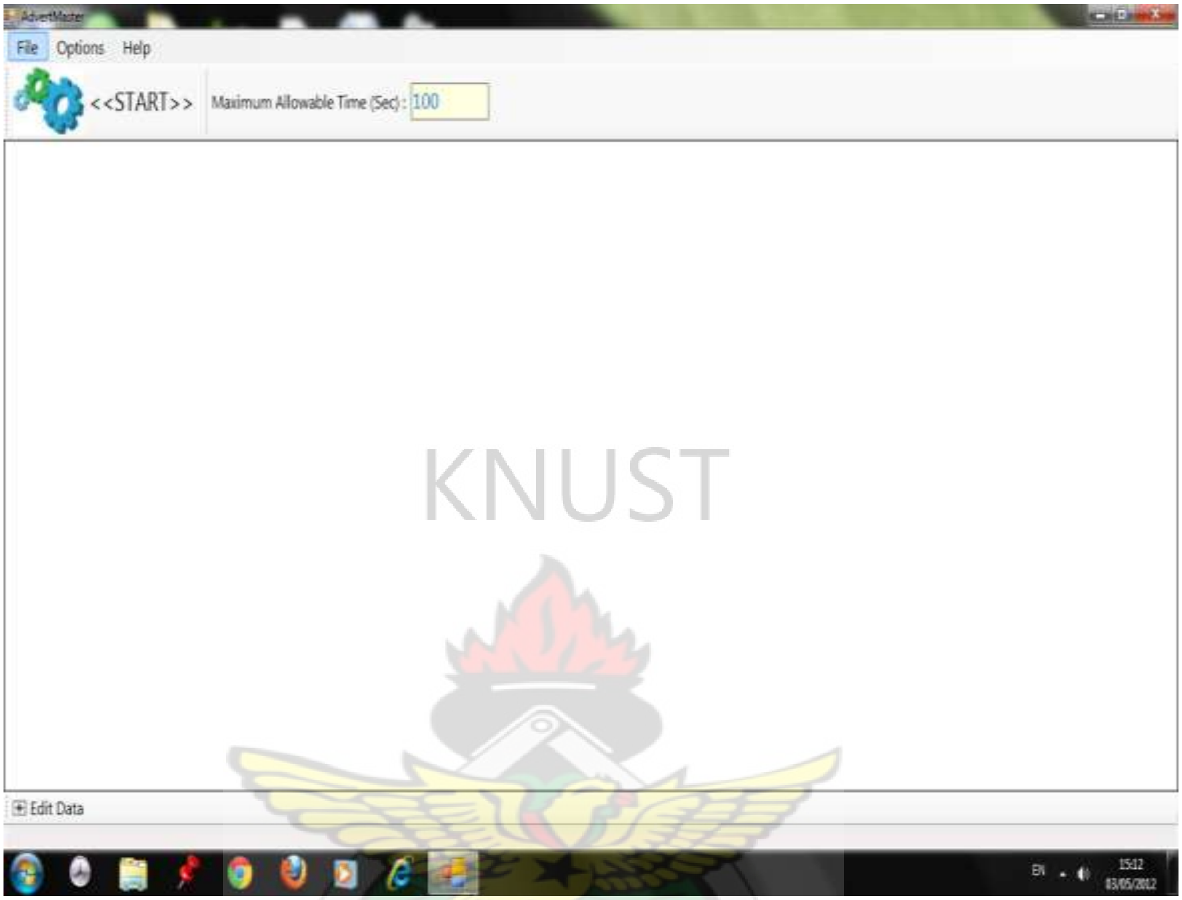


Figure 4.1 (Data entry from file user interface for ADVERT Master)

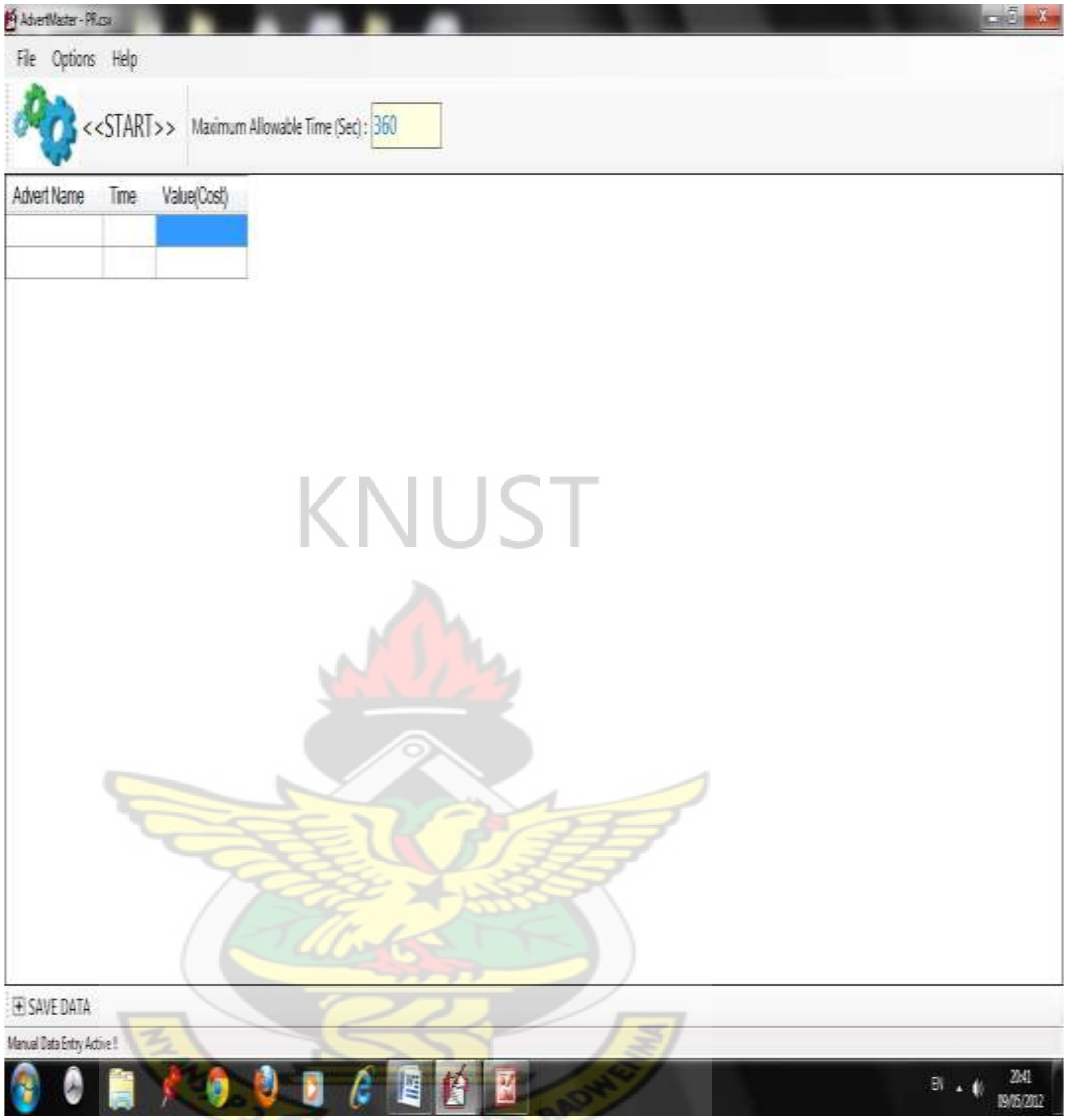


Figure 4.2 Manual data entry user interface for ADVERT Master

The software performs varying iterations depending on the number of items contained in the input file or entered manually. However, it displays the best three feasible solutions indicating the optimal solution within a second. This result can either be saved or printed out. For example, it performed 32 iterations on the data in table 4.7 given a time of 360sec. and displayed the result as below.

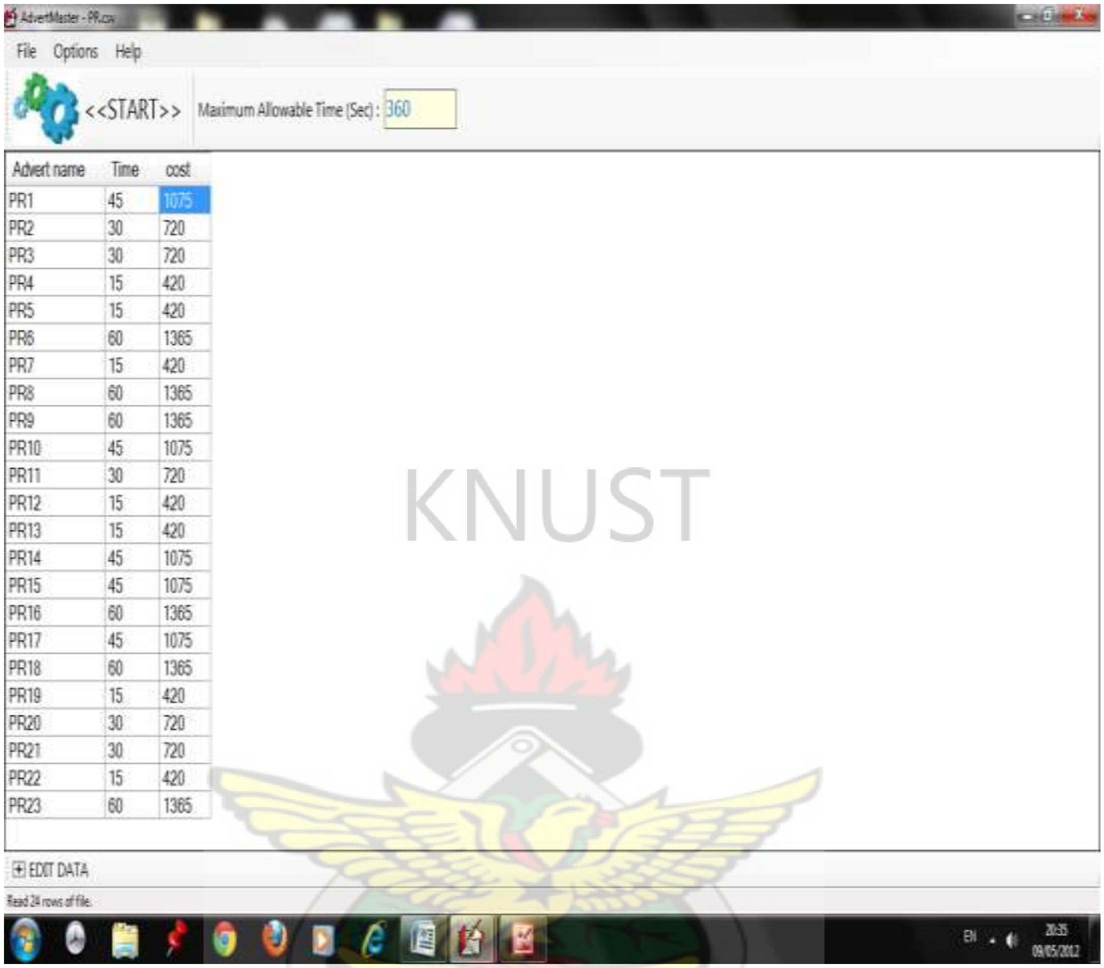
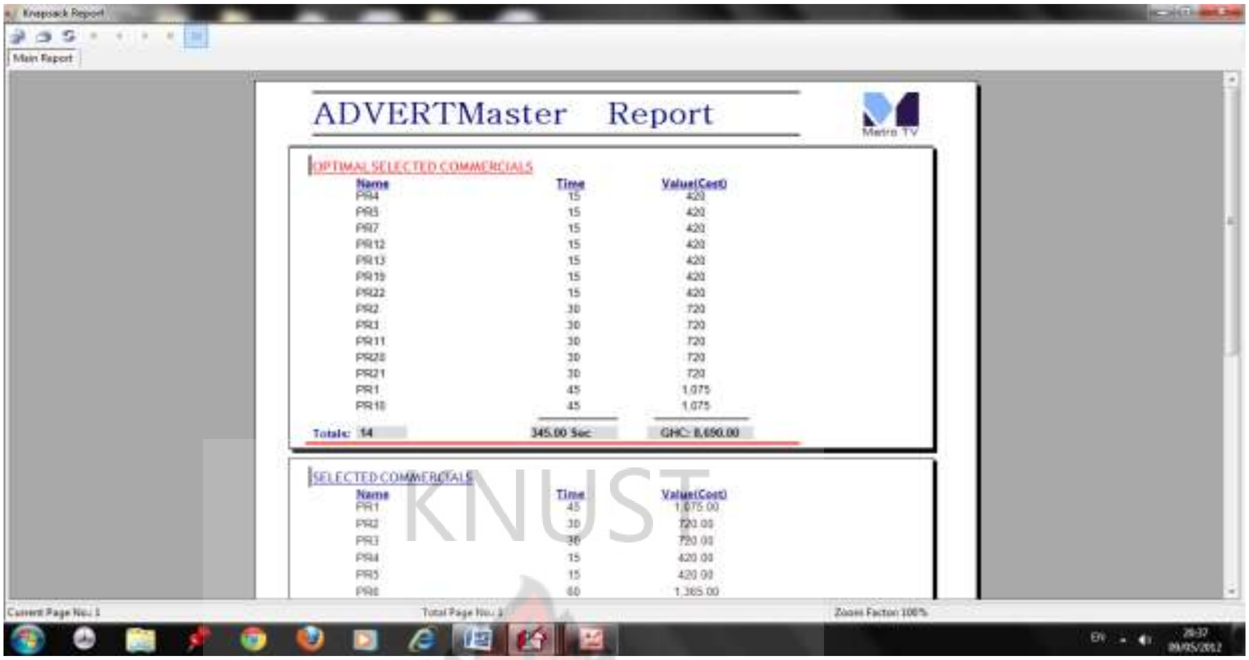


Figure 4.4 data entry from tab. 4.7



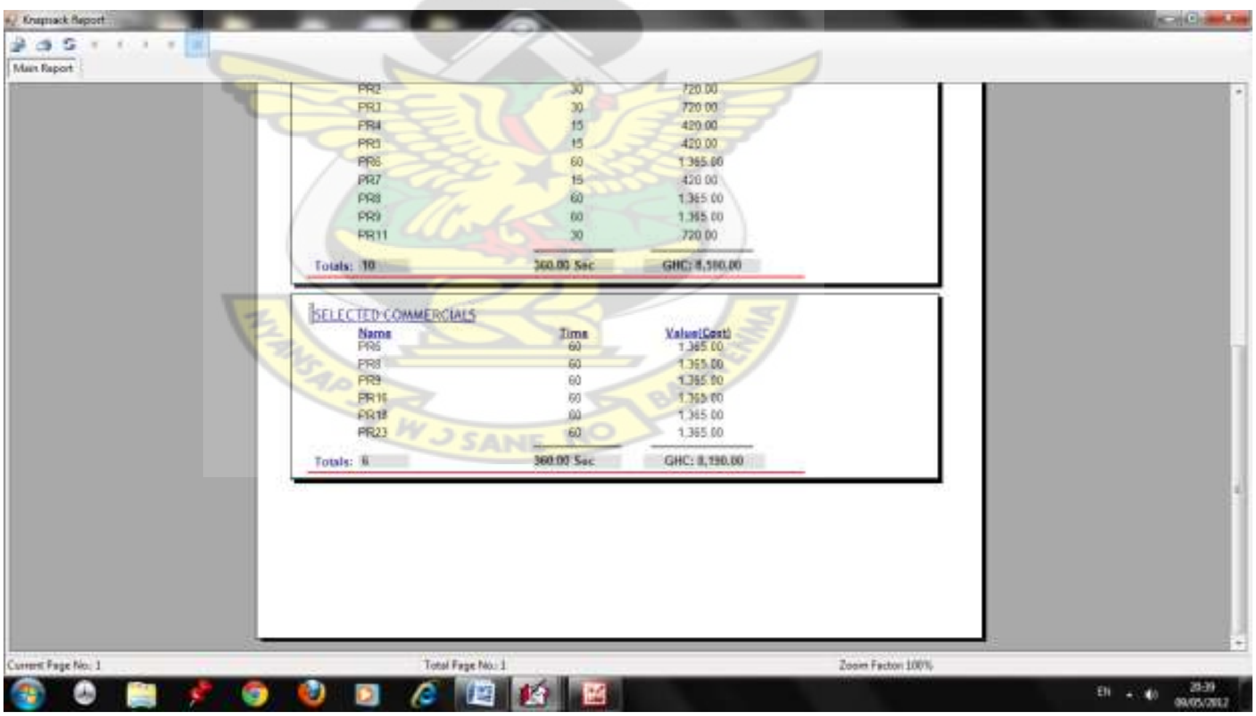


Figure 4.5 Display of result for data entered from tab. 4.7

RESULTS

Adverts selected at off peak time gave an amount of GH¢3940.00 daily with 10 out of 21 adverts selected at a weight of 360 seconds. The software generated an optimal structure of {0101011, 0010, 10100, 01011}.

Adverts selected at peak time were ten out of eighteen which gave an amount of GH¢10,200.00 daily and were played over a time of 360 second. The optimal structure generated by the software was {1100101, 010, 1001, 1110}.

Prime time adverts yielded GH¢8690.00 daily with 14 commercials selected out of 23 played over a 345 seconds period. The structure of commercials selected by the software at optimal was;

{1111111, 11111, 10001, 000000}

Premium time commercials played over a weight of 360 seconds yielded GH¢10,200.00 when the software selected nine adverts out of sixteen per day. The resulted structure was {10101, 0000,111, 1101}

Table 4.9 (summary of results)

Period	**Number of adverts available**	**Number of adverts selected**	**Available time (seconds)**	**Optimal value GH¢**
Off peak	21	10	360	**3,940.00**
Peak	18	10	360	**5,560.00**
Prime	23	14	345	**8,690.00**
Premium	16	9	360	**10,200.00**
Total	**78**	**43**	**1425**	**28,390.00**

CHAPTRE FIVE

5.0 INTRODUCTION

In this chapter, we shall put forward conclusions and recommendations of the study.

5.1 CONCLUSION

The purpose of this thesis was to design an efficient and effective way of organizing adverts in Metro TV, a private station in Ghana based on heuristics algorithm. We have shown that by using the algorithm, complemented with the computer solution, higher returns were achieved. For a particular day, an amount of GH¢28,390.00 was realized from the selection of 43 adverts for the four categories instead of GH¢21,000.00 when adverts were picked arbitrary. This may accumulate to GH¢851,700.00 in a month and GH¢3,406,800.00 over a four month period

The software which is easy to use is not only systematic, but also swift. It can produce and displays results within five seconds. It is therefore envisaged that higher results within the shortest possible time may be achieved when employed by Metro TV in the selection of their adverts.

In situations where particular adverts are of personal, the company or national interest, they could be isolated and their time sum deducted from the maximum allowed time before running the program to select the adverts.

5.2 RECOMMENDATION

We recommend that Metro TV uses the software to select adverts to be aired for better output

Whiles we focused on 0-1 knapsack algorithm, we suggest that future researchers may apply multi- knapsack algorithm base on similar ideas to the organization of adverts in same station or other TV and or radio stations. The concept of simulated annealing could also be used while the computer solution could be developed in Matlab language instead of VB Dot Net.

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APPENDIX A (Visual Basic Dot Net code for the Heuristic scheme)

Usin Ag System;

```
using System. Collections. Generic;
using System. Windows. Forms;
using System. Data ;

namespace CsvTest
{

    class Bag : IEnumerable<Bag.Item>
    {
        List<Item> items;
        public int Max Weight Allowed=0;
       public Data Table result Table ;

        public Bag()
        {
            items = new List<Item>();
            result Table = new Data Table();
        }

        void AddItem (Item i)
        {
            if ((TotalWeight + i.Weight) <= MaxWeightAllowed)
                items.Add(i);
        }
        public void Calculate(List<Item> items)
        {
```

```
            foreach (Item i in (items))
            {
                AddItem(i);
            }
        }

        List<Item> Sorte(List<Item> inputItems)
        {
            List<Item> choosen Items = new List<Item>();
            for (int i = 0; i < inputItems. Count; i++)
            {
                int j = -1;
                if (i == 0)
                 choosenItems. Add(inputItems[i]);
                }
                if (i > 0)
                {
                    if (!RecursiveF(inputItems, choosenItems, i, choosenItems.Count - 1, false,
ref j))
                    {
                        choosenItems.Add(inputItems[i]);
                    }
                }
            }
//choosenItems.Sort(0,choosenItems .Count,null );
            return choosenItems;
             }
```

```
bool RecursiveF(List<Item> knapsackItems, List<Item> choosenItems, int i, int lastBound, bool dec, ref int indxToAdd)
{
    if (!(lastBound < 0))
    {
        if (knapsackItems[i].ResultWV < choosenItems[lastBound].ResultWV)
        {
            indxToAdd = lastBound;
        }
        return RecursiveF(knapsackItems, choosenItems, i, lastBound - 1, true, ref indxToAdd);
    }
    if (indxToAdd > -1)
    {
        choosenItems.Insert(indxToAdd, knapsackItems[i]);
        return true;
    }
    return false;
}

#region IEnumerable<Item> Members
IEnumerator<Item> IEnumerable<Item>.GetEnumerator()
{
    foreach (Item i in items)
        yield return i;
}
```

```
#endregion

#region IEnumerable Members
System.Collections.IEnumerator System.Collections.IEnumerable.GetEnumerator()
{
   return items.GetEnumerator();
}
#endregion

public int TotalWeight
{
   get
   {
      var sum = 0;
      foreach (Item i in this)
      {
         sum += i.Weight;
      }
      return sum;
   }
}
public int TotalValue
{
   get
   {
      var Tval = 0;
```

```
            foreach (Item i in this)
            {
                Tval += i.Value;
            }
            return Tval;
        }
    }
    public class Item
    {

  public string Name { get; set; } public int Weight { get; set; } public int Value { get;
set; } public int ResultWV { get { return Weight - Value; } }



        public override string ToString()
        {


          // resultTable.Rows.Add(Name,Weight,Value);

            return Name + "," + Weight + "," + Value ;
        }
    }
}
```

APPENDIX B Weekly program line up for Metro TV.

2012 TV PROGRAMS

Time	Monday	Time	Tuesday	Time	Wednesday	Time	Thursday	Time
6:00	CNN WORLD NEWS	6:00	CNN WORLD NEWS	6:00	CNN WORLD NEWS	6:00	CNN WORLD NEWS	6:00
6:15	KEEP AFRICA FIT	6:15	KEEP AFRICA FIT	6:15	KEEP AFRICA FIT	6:15	KEEP AFRICA FIT	6:15
6:30	CNN WORLD OF SPORTS	6:30	CNN WORLD OF SPORTS	6:30	CNN WORLD OF SPORTS	6:30	CNN WORLD OF SPORTS	6:30
6:45	LET'S GO SHOPPING	6:45	LET'S GO SHOPPING	6:45	LET'S GO SHOPPING	6:45	LET'S GO SHOPPING	6:45
7:00	GOOD MORNING GHANA	7:00	GOOD MORNING GHANA	7:00	GOOD MORNING GHANA	7:00	GOOD MORNING GHANA	7:00
7:30		7:30		7:30		7:30		7:30
8:00		8:00		8:00		8:00		8:00
8:30	MUSIC BOX	8:30	MUSIC BOX	8:30	MUSIC BOX	8:30	MUSIC BOX	8:30
9:00	WHO WANTS TO BE RICH (REPEAT)	9:00	AFRICAN MOVIE (REPEAT)	9:00	MORNING RIDE (REPEAT)	9:00	CLASSIC BLOCKBUSTER MOVIE (REPEAT)	9:00
9:30		9:30		9:30		9:30		9:30
10:00	DOCTORS (REPEAT)	10:00		10:00		10:00		10:00
10:30		10:30	TOP 10 BOX OFFICE MOVIES	10:30	INSIDER HOLLYWOOD	10:30		10:30
11:00	MUSIC BOX	11:00	MUSIC BOX	11:00	MUSIC BOX	11:00	MUSIC BOX	11:00
11:30	GPL GAME	11:30	GPL GAME	11:30	GPL GAME	11:30	GPL GAME	11:30
12:00	EURO NEWS	12:00	EURO NEWS	12:00	EURO NEWS	12:00	EURO NEWS	12:00
12:15	LET'S GO SHOPPING	12:15	LET'S GO SHOPPING	12:15	LET'S GO SHOPPING	12:15	LET'S GO SHOPPING	12:15
12:30	MUSIC BOX	12:30	MUSIC BOX	12:30	MUSIC BOX	12:30	MUSIC BOX	12:30
13:00	NEWS @1	13:00	NEWS @1	13:00	NEWS @1	13:00	NEWS @1	13:00
13:30		13:30		13:30		13:30		13:30
14:00	SMARTER THAN A FIFTH GRADER (REPEAT)	14:00	ALLO TIGO (REPEAT)	14:00	SINBAD (REPEAT)	14:00	THAT'S SO RAVEN	14:00
14:30		14:30		14:30		14:30	WIZARDS OF WAVERLY PLACE	14:30
15:00	DANIELA (SATURDAY) REPEAT EPISODE	15:00	AFUTUSEM (REPEAT)	15:00	TOTAL WIPEOUT (REPEAT)	15:00	DOCTORS (REPEAT)	15:00
15:30		15:30		15:30		15:30		15:30
16:00	DANIELA (SUNDAY) REPEAT EPISODE	16:00	DANIELA (MONDAY) REPEAT EPISODE	16:00	AMERICAN IDOL (REPEAT)	16:00	SAAT PHERE (repeat)	16:00
16:30		16:30		16:30		16:30		16:30
17:00	INSIDER HOLLYWOOD	17:00	TOP 10 BOX MOVIES	17:00	INSIDER HOLLYWOOD	17:00	TOP 10 BOX MOVIES	17:00
17:15	LET'S GO SHOPPING	17:15	LET'S GO SHOPPING	17:15	LET'S GO SHOPPING	17:15	LET'S GO SHOPPING	17:15
17:30	LIVERPOOL TV	17:30	SOCCER XTRA (LIVE)	17:30	CHELSEA TV	17:30	SPORTS CAFE (LIVE)	17:30
18:00	SPORTS NEWS	18:00		18:00	SPORTS NEWS	18:00		18:00
18:30	AFUTESEM (LIVE)	18:30	SMARTER THAN A FIFTH GRADER	18:30	TOP 10 BOX MOVIES	18:30	MIND YOUR LANGUAGE	18:30
19:00		19:00		19:00	VODAFONE ICON'S HILITES	19:00	SAAT PHERE	19:00
19:30	NEWS NIGHT	19:30	NEWS NIGHT	19:30	NEWS NIGHT	19:30	NEWS NIGHT	19:30
20:00		20:00		20:00		20:00		20:00
20:30	ISLAM IN FOCUS	20:30	JUST A SECOND	20:30	DOCTORS	20:30	AFRICAN MOVIE	20:30
21:00	DANIELA	21:00	PRICE IS RIGHT	21:00		21:00		21:00
21:30		21:30		21:30	EXCLUSIVE WITH EDDY BLAY	21:30		21:30
22:00	CHELSEA TV	22:00	GOOD EVENING GHANA (LIVE)	22:00	LIVERPOOL TV	22:00	GOOD EVENING GHANA (LIVE)	22:00
22:30		22:30		22:30		22:30		22:30
23:00	LATE NEWS	23:00	LATE NEWS	23:00	LATE NEWS	23:00	LATE NEWS	23:00
23:30	DOCTORS (REPEAT)	23:30	TOTAL WIPEOUT (REPEAT)	23:30	PRICE IS RIGHT (REPEAT)	23:30	SAAT PHERE (repeat)	23:30
0:00		0:00		0:00		0:00	AMERICAN IDOL (REPEAT)	0:00
0:30	LIVERPOOL TV	0:30	CHELSEA TV	0:30	ARSENAL TV	0:30		0:30
1:00	LIVERPOOL TV	1:00	CHELSEA TV	1:00	ARSENAL TV	1:00	LIVERPOOL TV	1:00
1:30		1:30		1:30		1:30		1:30
2:00	AL JAZEERA NEWS	2:00	AL JAZEERA NEWS	2:00	AL JAZEERA NEWS	2:00	AL JAZEERA NEWS	2:00
2:30		2:30		2:30		2:30		2:30
3:00	CNN WORLD NEWS	3:00	CNN WORLD NEWS	3:00	CNN WORLD NEWS	3:00	CNN WORLD NEWS	3:00
3:30		3:30		3:30		3:30		3:30
4:00	DW-TV NEWS	4:00	DW-TV NEWS	4:00	DW-TV NEWS	4:00	DW-TV NEWS	4:00
5:00	AL JAZEERA NEWS	5:00	AL JAZEERA NEWS	5:00	AL JAZEERA NEWS	5:00	AL JAZEERA NEWS	5:00

OFF PEAK

PEAK

WEEKLY LINE UP

Time	Friday	Saturday	Sunday
6:00	CNN WORLD NEWS	CNN WORLD NEWS	CHURCH
6:15	KEEP AFRICA FIT	KEEP AFRICA FIT	
6:30	CNN WORLD OF SPORTS	MUSIC BOX	CHURCH
6:45	LET'S GO SHOPPING	LET'S GO SHOPPING	
7:00	GOOD MORNING GHANA	CHURCH	CNN WORLD NEWS
7:30		CHURCH	MUSIC BOX
8:00		CHURCH	CHURCH
8:30	MUSIC BOX	CHURCH	CHURCH
9:00	JOMAA ISLAMIC BELT	CHURCH	TOP 10 BOX MOVIES
9:30		CHURCH	MUSIC BOX
10:00		CHURCH	THAT'S SO RAVEN
10:30		CHURCH	WIZARDS OF WAVERLYPLACE
11:00		MORNING RIDE (LIVE)	MIND YOUR LANGUAGE
11:30			SINBAD Repeat
12:00	EURO NEWS		
12:15	LET'S GO SHOPPING		
12:30	MUSIC BOX	MUSIC BOX	MUSIC BOX
13:00	NEWS @1	DEAL OR NO DEAL	THANK GOD ITS FRIDAY (T.G.I.F) WITH KSM (REPEAT)
13:30			
14:00	MIND YOUR LANGUAGE	INSIDER HOLLYWOOD	
14:30	JUST A SECOND (repeat)	MUSIC BOX	GLO SUPER LEAGUE SHOW
15:00	PRICE IS RIGHT (REPEAT)	GLO PREMIER LEAGUE (LIVE)	GLO PREMIER LEAGUE (LIVE)
15:30			
16:00	SAAT PHERE (repeat)		
16:30	XCLUSIVE (repeat)		
17:00	INSIDER HOLLYWOOD	WEEKEND NEWS	GLO SUPER LEAGUE SHOW
17:15	LET'S GO SHOPPING		
17:30	SPORTS NEWS	WIZARDS OF WAVERLY PLACE	WEEKEND NEWS
18:00	SINBAD	THAT'S SO RAVEN	ASSIGNMENT
18:30		VODAFONE ICON'S	TOTAL WIPEOUT
19:00	SAAT PHERE	AMERICAN IDOL	
19:30	NEWS NIGHT		VODAFONE ICON'S
20:00		DANIELA	
20:30	DOCTORS		DANIELA
21:00		ALLO TIGO	
21:30	THANK GOD ITS FRIDAY (T.G.I.F) WITH KSM		WHO WANTS TO BE RICH
22:00		CLASSIC BLOCKBUSTER MOVIE	
22:30			ARSENAL TV
23:00	LATE NEWS		
23:30	SAAT PHERE (repeat)		
0:00	DOCTORS (REPEAT)	AMERICAN IDOL (REPEAT)	CLASSIC BLOCKBUSTER MOVIE (REPEAT)
0:30			
1:00	CHELSEA TV	ARSENAL TV	
1:30			
2:00	AL JAZEERA NEWS	AL JAZEERA NEWS	AL JAZEERA NEWS
2:30			
3:00	CNN WORLD NEWS	CNN WORLD NEWS	CNN WORLD NEWS
3:30			
4:00	DW-TV NEWS	DW-TV NEWS	DW-TV NEWS
5:00	AL JAZEERA NEWS	AL JAZEERA NEWS	AL JAZEERA NEWS

PRIME PREMIUM