

Application of Agent Technology in Telecoms Billing Systems: A Cost Benefit Analysis

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Abstract - The two prominent billing platforms, postpaid and prepaid billing systems currently in operation in Telecommunications have some problems. In postpaid the problems are mostly due to fraudulent activities by some employees that costs a telecommunications company a loss of 5% of its total revenue annually, and also inefficiency of some human personnel like the dispatch riders who dispatch or distribute bills. While the prepaid billing has its problems like inability to make calls at zero level credit, no matter how urgent and important that call is to the customer. In order to minimize these problems, a framework is proposed in this paper. Software Agent Technology is used by identifying some of the areas and personnel liable to fraud and inefficiency and substituting them with Software Agents. The Unified Modeling Language (UML) is used to model the proposed framework. Java as an Object-oriented programming language is used to come up with the prototype of the agent system, Visual Basic 6.0 was also used to code the processes involved in the three subsystems. This paper presents a cost benefit analysis of substituting some human personnel with software agents in executing some routing tasks, thereby minimizing cost and maximizing benefit.

Keywords: Software Agent, Telecommunication, Unified Modeling Language (UML), Call Detail Records (CDR), Cost Benefit Analysis.

1 Introduction

The transmission of messages, voice or data using telephone involves conversion of different types of information such as sound, video or text into electronic or optical signals. Electronic signals are transmitted using a medium such as copper wire or carried over the air wirelessly in form of radio waves. The optical signals travel along a medium such as strands of glass fibers. This is often called optical fiber (Frieden, 2009). Providing avenue for communication among people from one location to another is a service which will in turn attract some charges for the service delivery. It is obvious that telecommunications has touched the life of millions of people worldwide. A message that made people to travel long distance to deliver would be delivered using the telecommunications within few seconds, without having to take the risk to traveling especially on our dilapidated roads (Garko, 2008).

1.1 Overview of the postpaid billing

Postpaid billing is a type of billing platform in which customer (subscriber) pays for the services s/he has enjoyed; this is normally at the end of a billing period. In postpaid billing the customer may pay an insurance payment in advance, and s/he may pay the installations or setup fees, and in each billing cycle s/he will be invoiced (receive a bill) to pay for the usage of the service [6]. Telecommunications Companies need an effective and accurate billing system for revenue assurance [6].

Billing systems process the usage of network equipment that is used during the service usage into a single Call Detail Records (CDR).

Some authors also proposed the major billing activities as [1]:

- i. The rating engine: Processing the usage
- ii. The invoicing engine: Month-end processing
- iii. Clearing House
- iv. Invoices
- v. Management reporting
- vi. Bills distribution
- vii. Processing payments
- viii. Posting to the financial system

2 Overview of software agent technology

Since the beginning of recorded history, people have been fascinated with the idea of non-human agencies. Popular notions about androids, robots, cyborgs, and science fiction creatures permeate our culture, forming the unconscious backdrop against which software agents are perceived [2]. Software agent technology has been a research area in Computer Science that deals with substituting human user(s) by a group of computer programs that carry out the routine tasks autonomously with or without minimal human intervention. Generally, agent is software that represents users in the same way the users would represent themselves.

2.1 Typology of agents

Based on the properties of Software Agents (Learning, Autonomy, and Cooperation), an author suggested that software that has an intersection of at least two of the properties be regarded as an agent [10]. The agent types are listed below as proposed by [10].

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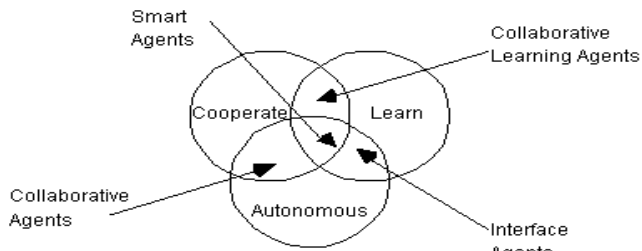


Figure 1: Part view of an agent typology [10]

- i. **Collaborative agents:** These are agents that emphasize autonomy and cooperation with other agents in order to carry out any task [10]. These agents may learn but learning is not emphasized as a requirement for job execution.
- ii. **Collaborative learning agents:** These are the same with collaborative agents, except that, learning is also emphasized apart from autonomy and cooperation in executing their tasks [10].
- iii. **Interface agents:** This type of agents uses learning and autonomy in order to execute tasks for their owners. A good example of this kind of agent is just like a personal assistant who works with the user in the same work environment [10], [8], [3].
- iv. **Smart agents:** these are agents that have all the characteristics of other agents; that is to say, they combine the behavior of interface agents, collaborative agents and collaborative learning agents [10].

2.2 Agent technology applications in telecoms

Telecommunications infrastructures looking at their distributed nature across a given region, country or the entire globe are natural application domain for the distributed or mobile software agent technology [9], [7].

3 Handling the billing activities by software agents

In order to have more efficiency, the problem to be solved by the software agents in the billing activity needs to be partitioned into smaller components or sub-problems; each component should be solved by a particular agent or group of agents. Solving the problem by a group of agents introduces the need for communication among the software agents.

3.1 Multi-agent system (MAS) design

This technique as suggested by experts in agent technology involves three (3) stages that represent Agent-based software life cycle as:

- i. **Decomposition** – This means breaking or splitting the complex system into various simpler sub-systems.
- ii. **Abstraction** – This involves the process of defining a simplified model of the system that emphasizes some of the details or properties, while hiding others. In this stage of Agent-based software life cycle, the concept of Unified Modeling Language is going to be used to come up with different Agent-UML designs as models of our Agent-based system.

- iii. **Organisation or Hierarchy** – After decomposing the complex postpaid billing system into various simpler sub-systems as: Pre-billing, Main billing, and Post-billing, and having identified the required number of software agents on the three sub-systems, the next step in the agent-based software life cycle is coming up with a hierarchy of agents as problem solving components.

3.2 Agent-oriented modeling method – some assumptions

When modeling a real world application domain using agent-oriented approach the following assumptions are made:

- i. Agents and objects can co-exist and have mutual relationship.
- ii. An active object can be regarded as an agent.
- iii. Agents act asynchronously.
- iv. Interactions among the software agents take place through exchanging messages.

4 Design of software agents for the postpaid billing system

The entire Billing System is decomposed into three (3) simpler sub-systems:

- i. **The Pre-billing system:** This sub-system encompasses all the activities that are carried out before the actual bills generation. The activities include:
 - a. **Customer administration** – This involves all activities relating to the update on customer's records like transfer, change of name etc. The activity is going to be carried out by Billing Administrator(s).
 - b. **Payments processing** – The recharge voucher's information is captured and stored in a text file not visible to any billing administrator. At a later date the file is used to update the payment table by a software agent called *PayProcessor Agent*.
 - c. **Call detail records (CDR) processing:** The CDR is sent to the Pre-billing system from mediation as a text file after conversion. The file normally consists of records of subscribers (customers) transactions within a period of time. The records are usually made up of: Calling number (*A_number*), Called number (*B_number*), start_time, end_time, duration etc. The CDR processing involves reading the content of the CDR file for rating, that is identify each records with its duration and multiply the duration by a certain amount of money.
 - d. **Transmission of the rated CDR to the billing server:** After processing the CDR files submitted to the Pre-billing system, the next activity is to ensure that all the processed or rated CDR files are transmitted safely to the main Billing Server for bills generation. The *CDRProcessor* is going to be in charge of this responsibility.

ii. **The Main billing system:** This system is going to be the one responsible for the main billing activities. The activities under this sub-system should include the following:

- a. **Bills generation:** This is the process that involves running of some billing scripts that update some database tables in order to generate what is called invoice (Bill) for the subscriber(s) of a particular telecommunication company. The process is going to be executed purely by a software agent called *BillGenerator*.
- b. **Reports generation:** Apart from bills generation another activity in the main billing system is the reports generation. This activity involves running of some billing scripts and modules to generate information for decision making in form of reports. The decision makers of the telecommunication company are the management staff of that Organisation. These reports are going to be generated by the *ReportGenerator* Agent.

5 System implementation

Having come up with the various designs of the components of our proposed system, for the results to be obtained and evaluated, these designs were implemented. In the implementation stage, a client-server network architecture was used with a number of Computer systems (four systems) one as the server and the remaining three as clients. Many user interfaces are designed while implementing the framework, among which is customer record modification module shown in figure 2.

Figure 2: User interface for customer record modification

5.1 System requirements

The experimental environment used comprised of a local area network (LAN) with four computers; table 1 outlines the specifications (and names) of each of the computers that was used to conduct the experiments, while the LAN comprised of a 16-port D-Link switch and UTP cat 5e cables in a star topology. Some web pages are designed to aid customer ease of bill settlement via internet as can be seen in figure 3.

Personal Information		Account Information : 100000		Closing Balance: -894	
Name of Customer	Ahmed Baita Garko	Opening Balance	Payments	Total Duration in secs	Credit Debit Adjustments Adjustments
Telephone No	05042000010	0	2250	4681	4000 3000
Address	SSQ 13 KUST Staff Qtrs				
E-mail Address	abgarko@yahoo.com				

Figure 3: Web-based customer bill settlement portal

The Relational Database Management System used for the purpose of the experiments was MySQL Server 5, the software agents were implemented with the installed J2SE platform, while the customer administration modules were implemented using Visual Basic 6.0. The Customer Settlement portal was implemented using Macromedia Dreamweaver and php scripting language. Many reports were generated after implementing the framework, among which is the customer billing report shown in figure 4.

CUSTOMER BILLING REPORT	
ACCOUNT NUMBER	100000
TELEPHONE NUMBER	05042000010
CUSTOMER NAME	Ahmed Baita Garko
CUSTOMER	SSQ 13 KUST Staff Qtrs
CITY	Wudil
STATE	Kano
SEX	Male
<hr/>	
OPENING BALANCE	0
AMOUNT CHARGED	2356
PAYMENTS	2250
CREDIT ADJUSTMENT	4000
DEBIT	3000
TOTAL DURATION	4681
CLOSING BALANCE	--N=894.00
<hr/>	
YOUR BILL FOR THIS MONTH IS: --N=894.00	

Figure 4: Customer billing report

6 Results and Discussion

After coming up with the results of implementing our framework, we tried to compare them with what is currently obtained or practiced in some four randomly selected telecommunication companies in Nigeria. The comparisons are shown in some tables and graphs under this section of the thesis. The results revealed the advantage of implementing our proposed framework as it will help a telecommunication company in minimizing fraud as the billing personnel are reduced to half (50%), Customer

service centre staff reduced to one quarter (25%), and also maximizes revenue by the same factor and improves efficiency in the overall operations in the postpaid billing system. The telecommunication companies are named: Company 1, Company 2, Company 3, and Company 4. Our framework is represented as "Agent_based" on the various tables and graphs that follow.

6.1 Downsizing the Billing and Customer Care Personnel:

In determining the number of billing personnel to be dropped by implementing our framework; we randomly selected Company 1 out of the four randomly chosen telecommunication companies in Nigeria. After exploring the structure of Company 1's billing department, we obtained the following data shown on table 1 below

Table 1: Billing Department Personnel for Company 1

Section	Number of Personnel	Percentage
Quality Control	37	18.5
Data Entry	39	19.5
Billing Administration	19	9.5
System Administration	23	11.5
System Development	22	11
System Maintenance	25	12.5
Billing Operations	23	11.5
Administrative Staff	12	6
Total	200	100

Basically, the personnel in Quality Control section collect input (CDR and payments) from territories and banks respectively. Since our framework has software agents that process and transmit CDR to the billing system and payments are captured directly by the customers eliminating a third party (banks), then the two sections, Quality Control and Data Entry are no longer needed by implementing our framework by any telecommunications company. In Company 1, it was also found out that, Billing Operations section deals with bills and reports printing and distribution to territories. With this development, if a company implement our framework then this section also becomes no longer relevant as the process of bills generation and distribution is entirely paperless. Combining the personnel of the three sections, Quality Control, Data Entry, and Billing Operations, this constituted about 50% of the entire billing personnel. We assumed this is obtainable in all the three other companies. Going by this assumption, we suggested any company implementing our framework should reduce its billing personnel by 50%. For Customer Care personnel, we use the same company and get the following data in table 2.

Table 2: Customer Care Center Personnel for Company 1

Section	Number of Personnel	Percentage
Credit Control	109	27.25
Business Office	58	14.5
Bills Distribution	97	24.25
Customer Complaints	42	10.5
Payments	94	23.5
Total	400	100

From table 2, if Company 1 implemented our framework, it will not need the services of the personnel in Credit Control, Bills Distribution, and Payments sections. This is due to the following reasons:

- Credit Control updates customers' payments in ledgers for reconciliation with the Billing department. As customers directly capture their payments, so, there is no need for this section.
- Bills Distribution section collects the bills from the Billing department and distributes them to the various subscribers via the dispatch riders. Implementing our framework, this section is no longer needed.
- Payments section personnel go to the banks on daily basis to collect the finance copy of the quadruplet bank tellers of customers' payments for onward transmission to the Billing department. Implementing our framework, this section is no longer needed as banks are eliminated. Customers directly settle their bills directly using recharge vouchers or their ATM cards.

Looking at these three sections, Credit Control, Bills Distribution, and Payments, constituting about 75%, we suggested dropping them and go with the remaining 25%. Assuming this is obtainable in all the three other randomly selected telecommunications companies.

6.2 Substituting some personnel with software agents

Some billing personnel and customer care centre staff according to our proposed framework are going to be reduced to minimize expenditure, minimize fraud, and maximize revenue for a telecommunication company. The graphs below summarize the implications of reducing the number of billing personnel to 50% and customer care centre staff to 25%.

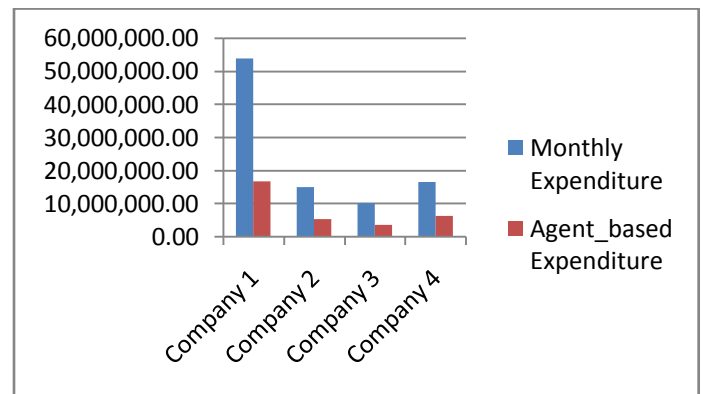


Figure 5: A Component Bar Chart for Monthly Expenditure for the four Companies in Naira

The advantage of substituting some billing personnel with software agents and the subsequent reduction of customer care centre to 25% can be seen in figure 5 where the total monthly expenditure on salaries, allowances and overhead cost of running the two departments are drastically reduced to 35%. So for any company implementing our framework proposal may save between 60 and 65% of the monthly expenditure of its billing and customer care departments. This is clearly shown in figure 6.

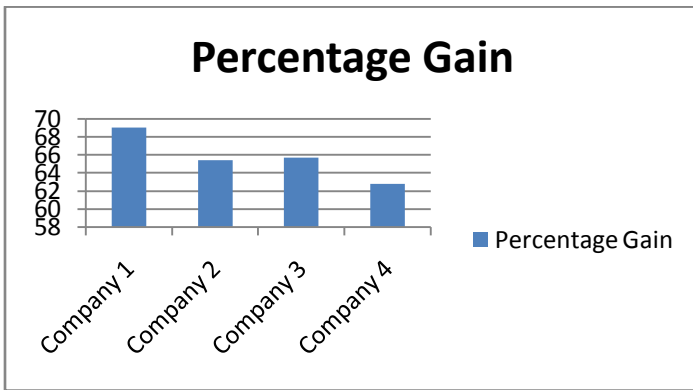


Figure 6: Percentage gain for the four companies by using our Framework

The percentage gains of each of the four companies are shown in figure 6, which shows company 1 may gain around 69%, company 2 65%, company 3 65%, and company 4 more than 62%. The gain in this concept is the amount a company may save from its current monthly expenditure.

$$\begin{aligned} \text{The average gain} &= (69 + 65 + 65 + 62)/4 \\ &= 65\% \end{aligned}$$

So, the average saving a company may have on salaries and overhead cost monthly after implementing our framework may be up to 65% of its current expenditure on the same purposes. Making the operations purely electronic thus, eliminating the need for printers and printer cartridges as well as papers for the bills printing will save a company huge amount of money as shown in the previous graphs. What substitutes these materials for bills printing is the cost of hosting a web site or billing settlement portal. The figures below show that still the advantage is clear when we tried to compare the gains with the cost of hosting a website for the individual telecommunication companies we have been dealing with. From the list of prices for hosting a website for year and looking at the voluminous nature of data telecommunication companies handle on daily basis, the sum of one hundred thousand naira (₦100, 000.00) is assumed as the monthly cost for hosting a website for a company like the four we are dealing with.

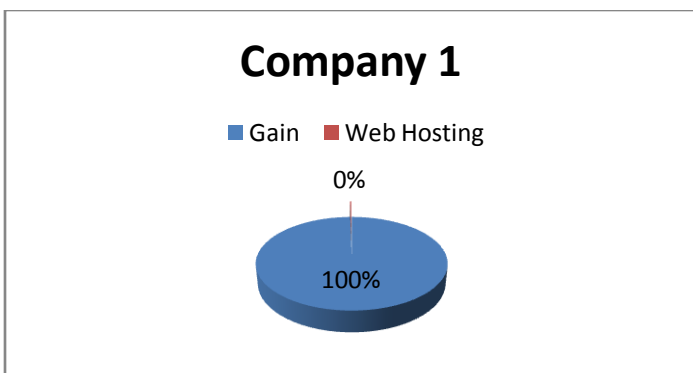


Figure 7: Company 1 gains compared to the cost of Web Hosting

For company 1 it can be seen in figure 7 that less than 1% of the gain may be spent to pay for the monthly cost of hosting the customer payment portal. This is quite negligible.

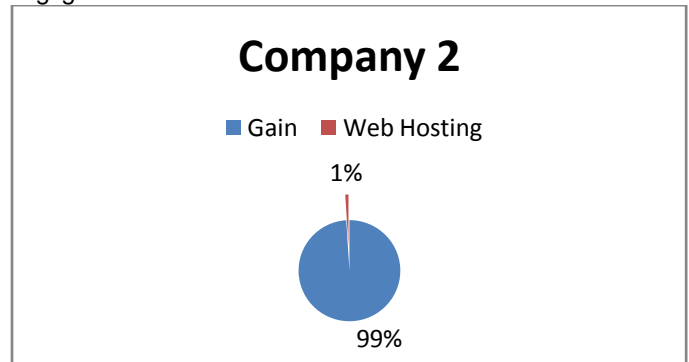


Figure 8: Company 2 gains compared to the cost of Web Hosting

For company 2 also 1% of the monthly savings by the company may be used to host the payment portal. This is shown in figure 8.

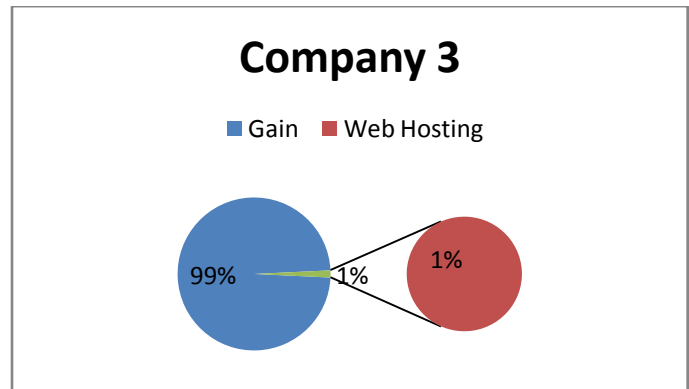


Figure 9: Company 3 gains compared to the cost of Web Hosting

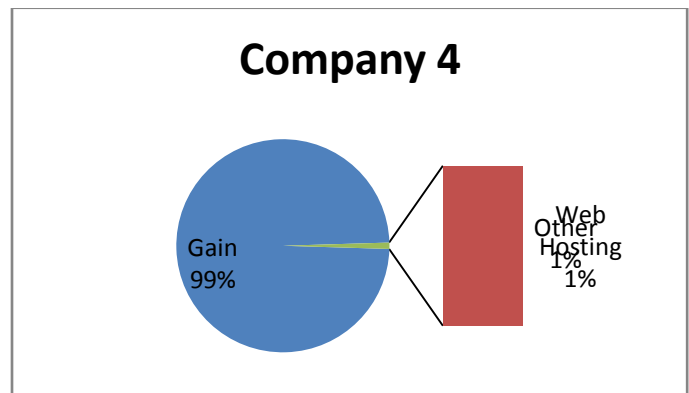


Figure 10: Company 4 gains compared to the cost of Web Hosting

From figures 9 and 10 companies 3 and 4 may each spend 1% of the monthly on paying for the web hosting. This is quite affordable considering the millions a company may save monthly by implementing our framework.

6.3 Cost Benefit Analysis for Implementing our Framework

So far we have been seeing the benefit when our framework is implemented by a telecommunications company in the previous sections. This is not enough to convince the telecommunications industry. In order to have the telecommunications companies and the world at large convinced, there is need for a comparison of the Benefit to be gained as a result of implementing our framework with the cost implications of paying off the downsized personnel their gratuities and pensions, also the cost of deploying the new system from Analysis, Design, to training the remaining personnel on how to go about using the new system, together with the hardware and software cost implications as a result of implementing the Agent-based framework. In this section of the thesis, two companies are randomly selected out of the four companies we have been dealing with in this research. These are Company 2 and Company 4. To show the Benefit to be derived by implementing our framework we used the following table:

Table 3: Benefit to be derived by implementing our framework in naira (₦)

Company	Savings S & A	Savings for Fraud Cut	Monthly Total	Yearly Total
Company 2	9,751,666.66	1,750,000,000.00	1,759,751,666.66	21,117,019,999.92
Company 4	10,321,666.66	630,000,000.00	640,321,666.66	7,683,859,999.92
Total	20,073,333.32	2,380,000,000.00	2,400,073,333.32	28,800,879,999.84

From table 3, it can be shown that Company 2 will benefit by implementing our framework yearly by saving up to ₦21, 117, 019, 999.92 from the savings on salaries, allowances and overhead cost plus the 70% savings of the expected money to be lost as a result of fraud and irregularities in the billing system. Likewise, Company 4 will benefit yearly with ₦7, 683, 859, 999.92 as a result of the same factors mentioned earlier for Company 2. After seeing the Benefit to be derived by implementing our framework as the positive aspect of the new framework, we now show the cost implications as the negative aspect of the new framework. Finally, the two are compared to see which overweighs which. The following table shows the cost implications of implementing our framework by Company 2 and Company 4.

Table 4: Cost Implications of Implementing our Framework in Naira (₦)

Company	Staff Benefit	Hardware Cost	Software Cost	Staff Training	Total
Company 2	1,000,000,000.00	500,000,000.00	500,000,000.00	100,000,000.00	2,100,000,000.00
Company 4	1,000,000,000.00	500,000,000.00	500,000,000.00	100,000,000.00	2,100,000,000.00
Total	2,000,000,000.00	1,000,000,000.00	1,000,000,000.00	200,000,000.00	4,200,000,000.00

From table 4, it can be seen that each of the two companies will spend roughly two billion naira (₦2, 100, 000, 000.00) to implement our framework. This is by assuming that, since each company will pay off 100 personnel at the cost of ten million naira per personnel, and also assuming that ₦500, 000, 000.00 is going to be spent by both companies to update their systems (hardware and software), in addition to ₦100, 000, 000.00 to be spent by each company on staff training.

Table 5: Benefit and Cost Implications Compared in Naira (₦)

Company	Benefit	Cost	Difference
Company 2	21,117,019,999.92	2,100,000,000.00	19,017,019,999.92
Company 4	7,683,859,999.92	2,100,000,000.00	5,583,859,999.92
Total	28,800,879,999.84	4,200,000,000.00	24,600,879,999.84

From the above table, it can clearly be seen that Benefit overweighs the Cost implications when a telecommunications company implements our framework. This can be seen for Company 2 that it will benefit with a sum of ₦21, 117, 019, 999.92 and will spend only ₦2, 100, 000, 000.00 in implementing our framework. For Company 4 also, the Benefit of implement our framework overweighs the Cost of implementation. From the above, we can conclude by saying that, a telecommunications company will benefit by implementing the Agent-based Billing framework that minimizes expenditure, fraud, and revenue leakages. This can also be shown graphically in figure 11 below

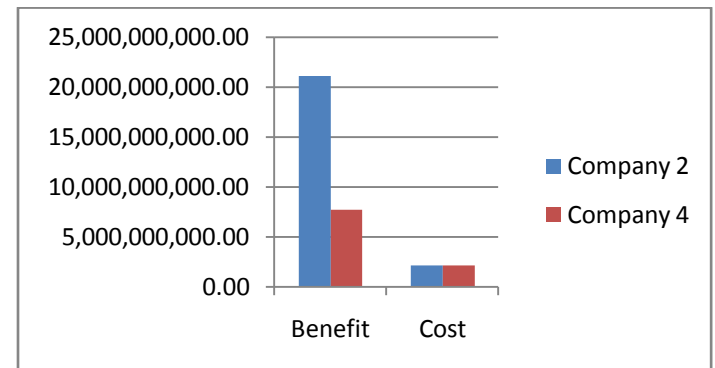


Figure 11: Cost Benefit Analysis by Implementing our Framework

7 Conclusion

This paper presents a cost benefit analysis of implementing a framework for building of an efficient Postpaid Billing System in Telecommunications using Collaborative Software Agents. The methodology adopted is the Agent-based software engineering technique which extends the traditional Object-oriented technique. The Unified Modeling Language (UML) was employed in coming up with the designs. The results obtained from the prototype of the system show a significant reduction in paper work thereby minimizing cost; the results also presented the elimination of third party in customer bills settlement, where customers directly credit their accounts. Fraud was also minimized by substituting some humans with software agents. The analysis has shown a great difference with the benefit overweighing the cost of implementing our framework. Therefore, any telecommunications company willing to implement our framework of substituting corrupt human personnel with software agents may likely boost its revenue by minimizing expenditure and fraud, and on the other hand by maximizing efficiency and profit.

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