ISSN No. 0976-5697

Volume 2, No. 2, Mar-Apr 2011

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

Reengineering of the Tollgate Process Management based on the Financing of Road Infrastructure in Developing Countries

Roger Atsa Etoundi*
Department of Computer Science
Faculty of Science
University of Yaounde I
roger.atsa@uy1.uninet.cm

Tchatchouang Kepche Stéphanie
Department of Computer Science
Faculty of Science
University of Yaounde I
tkepch2006@yahoo.fr

***Abstract*:** To manage its road assets, the Republic of Cameroon opted for the creation of tollgates on tarred roads to finance the road sector because of the limitation of public funds which is a general problem in developing countries. The funds collected should be used to maintain existing roads and create others. After several years of prosperity during which revenue from tollgates were significant, there came a point from where a significant drop in tollgate revenue was experienced despite the creation of new tollgates and the increase number of vehicles. This drop in revenue is largely due to poor monitoring of various operations related to the management of the different tollgates which is systematically manual. This type of processing has encouraged all sorts of fraud, resulting to the drastic drop in revenue. In order to boost the revenue related to the management of tollgates, we handle this problem as one of engineering. After defining salient concepts suitable in representing a tollgate, we build in an incremental manner a model for an efficient management of tollgates based on the use of ICT.

Keywords: Tollgate Management, Revenue Security, Business Process Reengineering, Quality of Service.

I. INTRODUCTION

Most developing countries depend on traditional sources for financing and investing on roads. As a result the construction resources and maintenance of roads is often inadequate and unsustainable. To meet this challenge, countries have implemented various initiatives such as the establishment of road toll systems with an efficiency of funding. Moreover, there is a general lack of maintenance funds in almost all countries in the developing world [12]. Most government allocations for maintenance of roads remain well below the amounts necessary for the conservation network. In many countries operating budgets have declined to the point where they barely cover staff costs, administration and some emergency repairs. There is little for maintenance. In the past, international agencies gave their assistance insofar as they have essentially supported the investment budgets, but now they are no longer willing to finance rehabilitation projects without credible arrangements for road maintenance [13,14]. The insufficiency of financial resources to maintain existing roads and create more roads is a real impediment on development of developing countries. Moreover, the poor infrastructures in these countries have direct and indirect important impact on humans such as accessibility to health care centers and a real hindrance to the development of different sectors that depend on it. Although not explicitly outlined in the Millennium Development Goals (with the notable exception of access to water and sanitation), infrastructure development undoubtably contributes to their achievement. For these reasons, the cost of transport is particularly high in these countries, averaging 14% of the value of exports compared to 8.6% for all developing countries. It even reached 50% on average in the 15 landlocked countries in these countries. Only 27.6% of 2 million kilometers of roads are paved in Africa generally, a figure that drops to 19% for Sub Sahara African countries, compared to 27% in Latin America and 43% in South Asia [15]. Development and modernization of infrastructure in Africa to achieve the MDGs by 2015 would require substantial investment among, according to the World Bank, about $ 40 billion per year over the decade 2005/2015 (9% of GDP) Including $ 22 to 24 billion investment in new infrastructure and $ 17 billion for maintenance of existing infrastructure [16]. Public resources alone will not suffice to bridge the considerable gap that exists between the infrastructure available and the needs of these countries' population. For example, it is estimated that on average, African countries would be able to maintain less than half of their national road networks, if they were counting on their own budgetary resources. Consequently, many African countries have sought to involve the private sector in development and infrastructure management.

Roads constitute a prior medium to any economic development in developing countires. It can generate funds for its development by involving road users. That is why many developing countries are making substantial investments in equipping them with road infrastructures [3] that facilitates meeting the defined objective. Cameroon is not left behind in this new deal. Cameroon now has more than 4054 km of tarred roads as compared to 2,796 km in 1986 [5, 6]. Faced with the ever increasing need of road infrastructure due to the requirement of adapting the road sector to the development of the country, the state was in difficulty to achieve the goals set in maintaining existing roads and creating new ones. These difficulties worsened with the economic crisis that struck the

world. The state had to find solutions to meet the requirements in the road sector. Also, during 1992/1993 fiscal year, the associated finance law instituted the tollgates which aim is to ensure the recovery of maintenance charges and renewal of road infrastructure by road users; to increase State budgetary resources, and to meet up conditions of competition between different modes of transport.

Prime Ministerial decree No. 93/034 of 07 January 1993 from the Head of Government defines the modalities of the creation of tollgates on certain tarred roads of the national road network while the decision No. 003/A/MINAT of February 18, 1993 created 35 checkpoints which become operational from 30 November 1993. This number increased from 35 at the beginning to 45 today due to the construction of new roads.

In 2005, after twelve years of management of tollgates around the country, it has been realized that among the tarred roads, only 26% were maintained and were in good state, while the rest were just mediocre or bad and require immediate service. Moreover, it has also been established that the road density amounted to about 3Km per 1000 inhabitants and 100 km for 1000km^2 against an African average of 4.2 km for 100km^2 [6]. Instead of improving its road infrastructure based on the payment of fees by road users, this sector collapses for lack of funds to maintain existing roads. To remedy this state of affairs, maintenance and construction of road networks in Cameroon was estimated at approximately $189 million per year, development partners allocate annually to the State of Cameroon approximately $100 million; the remainder is on the responsibility of the state and is distributed such that the tollgates should provide $12.7 million approximately from 2006 with an annual increase aimed to reach $17, 8 million by 2012 [5]. But this goal was not achieved after the evaluation done in 2009, tollgates revenue continues to decline while road users increase significantly. Indeed, according to the cabinet meeting report of 25 June 2009, the government branded the drop in tollgate revenue estimating over $7.8 million average annual deficit between 2003 and 2007 [2]. Concerning the causes of this decline, speculations diverge. At the National road council, the structure in charge to reflect on ways and means for a harmonious development and maintenance of national road network, members point out the mismanagement of the road revenue securing Program which was established in October 2005 with aim to secure associated revenues and to go against the mismanagement of tollgates [1]. Faced with this situation, the Head of Government called for further efforts to streamline the income of the tollgates in the loop made up of roads linking the capital Yaounde to Douala and Bafoussam. Experts say the tollgates installed on these loop provide about 80% of road toll funds. Moreover, the national road council also points out that the manual process was subject to a lot of suspicions; the government therefore has suggested the urgent automation of tollgates, along with the necessary reform of the Road Fund [2].

To guide the Cameroon Government in its efforts to automate the management of tollgates, we propose a model based approach based on the business processes requirement [10, 11] for an efficient management of the income of tollgates in Cameroon. It involves creating conditions for continuous improvement of work by the actors themselves to reduce delays and errors in order to optimize the performance in building and maintaining roads [7]. For this goal, the quality of service [8, 9] in this sector will significantly be ameliorated.

The rest of the paper is organized as follows: Section 2 will present the tollgate system as it currently operates in Cameroon and the limitations of this system. In Section 3, we shall propose a solution to secure revenue. In Section 4 we shall propose an implementation of the prototype while section 5 concludes and prospects.

II. THE CURRENT SYSTEM

In this section, we shall present the current management approach of tollgates in Cameroon. This revolves around: tollgate payment modalities, the supply of tickets tollgate to be distributed to road users after payment for any eventual verification, the organization of work at each tollgate, monitoring and evaluation of tollgates, the operational assessment of tollgates, and fraud observed in this sector.

A. Modalities of payment of tolls and subscription

Tarred roads of the national road network comprise one or more toll checkpoints. These routes and the number of toll points on each are fixed by decree of the Minister of Transport. The crossing of any toll point is subject to the purchase and presentation of a ticket worth $1.1 issued by the Minister of Finance. This ticket must be stamped.

However, subscription packages at reduced rates for a route not going beyond a toll checkpoint may be granted to users who have their homes or workplaces in the vicinity of an tarred toll road for a route that does not go beyond a toll station: $ 11.11per month per vehicle, for vehicles of local public services on missions around their domain of competence: $11.11 per year per toll station per vehicle, for at most fifteen (15) seat public transport vehicles frequently used for activities around a single toll gate: $ 44.44 per month per vehicle. A subscriber card is purchased from the treasury to which the toll gate concerned is attached. However for public services, this card can be issued by the competent Paymaster General of that territorial jurisdiction.

Failure to present a ticket or a valid subscriber card after crossing a tollgate is punishable by a fine equivalent to six times the price of a toll. The fine is paid at the tollgate in exchange of tickets of equal value to the amount of the fine.

Authorized users toll are free. These are pedestrians, two-wheeled vehicles, ambulances, vehicles participating in law enforcement with number plates of the armed forces, the national gendarmerie and national security.

B. Access to Tickets

The Director of the Budget is the depository accountant of toll tickets and subscriber cards. He is responsible for the safekeeping of these tickets and the supply of major accounts office. His responsibility extends to transactions carried out by agents under his command. In case of loss or theft of tickets,

he cannot be discharge of that responsibility until the production of required regulatory justifications. The Paymaster General is supplied by the Director Budget and in turn supplies secondary accounts offices in their area of competence. The officials of the said accounts offices are bound to keep auxiliary account records and shall send monthly statements of their sales to the attached Paymaster, as well as the Directors of the Budget and Treasury. The proceeds of the sales are deposited at the state budget and final Budget allocation specified clearly at the time of establishment of the receipt. The Directors of the budget and the Treasury shall each carry out periodic verification of the regularity of sales and compliance of tickets in service.

C. Work organization

The checkpoint operates 24 hours on 24 under the care of three teams each consisting of six (6) persons. However, the number of agents appointed to the toll stations may be reduced in certain gate due to the amount of traffic. In case of staff insufficiency in one from the above government service, the local committee may seek the services of agents of other territorially represented government services after a favorable opinion from the competent senior staff.

Civilian personnel in service at the tollgates are appointed by order of the Governor on proposal of local representatives of the Ministry of Finance and Transport as appropriate. Personnel under the forces of law and order are by their competent commanding officer, at the request of the Governor.

The necessary hardware for the normal functioning of a tollgate is made for by the Transportation Authority; these include records and bags in which counterfoil-book of toll tickets are stored. A joint team ensures continuous control of tollgates. It is composed of a representative from the Divisional finances control (member) and a representative from the competent Provincial transport service.

Each team works continuously for 24 hours, from 8:00 to 8:00 the next morning. The whole team starts work at 07:30 am and shall sign out and authenticate tickets before relieve of the next team. It returns to duty 48 hours later. The cashier of the team must have a quantity of tickets worth more than the daily norm of the gate. Under the supervision of the team leader, he shares these tickets amongst sales agents present and records in the station register, the serial numbers of tickets issued to each of them. Each agent returns unsold tickets to the cashier who shall return them at the same time with the income of the day to the attached accounts office.

A daily income evaluation sheet, kept by the cashier and under the supervision of the team leader, is made available to each team. This form must imperatively indicate clearly the number of tickets sold by each agent as well as his signature to attest the exactitude of the amount of his receipts of the day. The sales of each agent in a team must be fully recorded in the register at the toll gate and deposited over to the cashier of the attached accounts office at the end of work in exchange of a receipt duly discharged. Upon resumption of service, the team leader has the records the number of the said receipt in the register of the station. In case of non presentation of this receipt by the cashier, the team leader informs the president of the local committee who takes precautionary measures.

D. Monitoring and Evaluation of agents

The toll gate is managed by an inter-ministerial operations monitoring committee, which is responsible for monitoring and coordinating the workflow of toll gates on the national territory. As such, it is particularly in charge of: (1) adopting strategies, action plans and corrective measures developed by the competent executive organs, (2) taking all necessary steps to start, the implementation and monitoring of the implementation of activities of toll gates on the national territory, (3) evaluating current toll gate activities and propose any appropriate corrective action, (4) adopting technical standards for equipment and materials at toll gates, on the basis of proposals from relevant technical services; (5) proposing to the Minister of Public Works and that in charge of finance, toll gates management modes, (6) producing toll gate statistical data, on the basis of documents produced by the competent technical services, (7) monitoring and supervise the management of toll gates. Besides the inter-ministerial committee, local committees for monitoring the operations of toll gates were introduced in order to carry out monthly assessment of toll gates in accordance with assessment guide prepared for this purpose. Despite all these measures set by text putting in place monitoring and management organs for toll gates in Cameroon, there is a failure to take into account all requirements for the proper management of those toll gates.

E. The Fleet vehicle

Since the mid-90s, the fleet vehicle has grown steadily, helped by the implementation of policies of trade liberalization and the massive importation of used vehicles which account for more than half of imported vehicles. This park has risen by nearly 210,000 vehicles in 2000 to approximately 313,000 vehicles in 2005, representing an average annual increase of 8.30%. It is divided into 82% of light vehicles and 18% heavy vehicles. The rate of car ownership, one of the highest in the region is about 14 per 1000 inhabitants [5,6]. According to the information received from the ministry of transport dealing with the delivery of cars license, the number of vehicles recorded from the year 1996 to the year 2008 is given by the following:

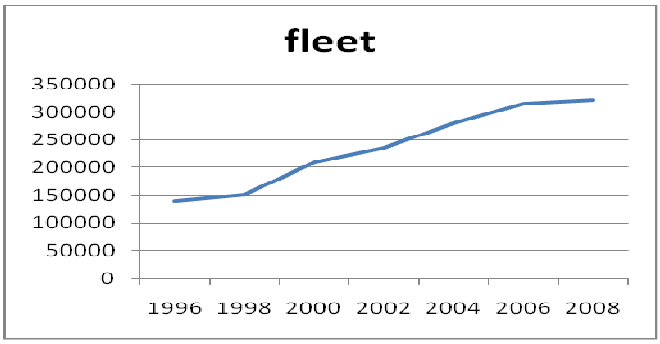

Figure.1 curve of fleet vehicle evolution

Based on these data, the number of vehicles has increased within the years. However, the revenue obtained from the management of tollgates does not follow this evolution although these vehicles used the roads where tollgates are deployed.

F. Tollgate functioning Assessment

The histogram below shows the revenue trend from the tollgates from the years 1995 to 2007:

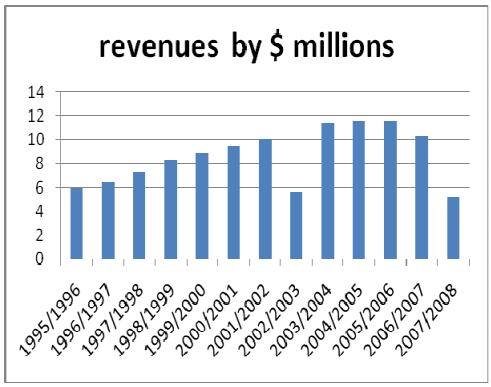

Figure.2 histogram tollgate revenues from 1995 to 2007

In total, over $ 12.7 million was collected within this period. In general, there is a trend of rising road tollgate revenue since its establishment, which increased from less than $ 4 500 000 in 1993-1994 to more than $ 10 million in 2006, but we cannot help noticing a decline of more than 10% between 2005 and 2006 accelerated in 2007. The communiqué endorsed by the cabinet meeting of June 25, 2009 notes that the toll road no longer gives the full measure of its ability. The government says it has received less than 62% of what users should pay [1]. A very high rate of fraud and questionable management justify the loss in revenue.

G. Tollgate frauds

The tollgate is defined by the laws that are readapted on the field according to the context. From these laws are defined a set of activities which should be carried out in order to make sure that the process is implemented as defined. Among these activities is the control process which allows to really verify what is done on the field. A control carried out in 1999 as part of the simplification and harmonization study of road tax in Cameroon around 4 tollgates and by linear interpolation on all the tollgates in activity revealed a fraud rate of 50% [5]. Meanwhile, an investigation by an inter-ministerial committee headed by the Ministry of Transport has recorded the following data based on one working day in all the tollgates:

Average taxable traffic (number of cars)	31 137
Estimated revenue	$34250.7
Actual revenue	$8888.9
deficit	$25361.8

On the basis of statistical data above, the fraud rate is estimated at about 73%. Following an analysis of the operation described above, we can identify two reasons for this state of affairs (1) the inability to know the exact number of vehicles passing through a given tollgate. This implies that fraud of all kinds can be arranged at the toll gate from an agreement between users and road tollgate personnel (i) cash payment that will not be counted. The government spoke of the existence of parallel tickets, the sale of tickets is not recorded, (ii) reuse of denatured tickets that are dispatched to distracted users as pointed out by "Cameroon Tribune" in its issue of July 10, 2009 publication (iii) Non-payment of tolls due to relations of friendship and brotherhood between tollgate personnel and road users, (2) manual management of tollgates that does not facilitate the monitoring, evaluation and traceability of all operations.

III. REENGINEERING OF TOLLGATES PROCESS FOR BETTER MANAGEMENT

To secure the revenue from tollgate, in this section, we define the salient concepts that will be used in order to build the required model. For this, we shall consider that a tollgate consists of a set of toll payment zones. Each zone is characterized by a sense of traffic that is either up or down, two barriers (an inlet and a outlet), an electronic counter, a waiting space where road users are positioned when the electronic counter is under used.

The electronic counter consists of a card reader and a cash payment device. Each detected vehicle is automatically registered in the database as soon as the latter finds itself at the electronic counter. The entry barrier is characterized by an electronic bar that is either open or closed, and a detector of cars in the queue. The entry opens automatically when a car is detected in the queue and the electronic counter is free. For a good understanding of our model, we shall present in an incremental manner the various concepts discussed above.

A.User

In this work, we consider as user any vehicle that uses a toll route on which we have installed a tollgate. The current legislation recognizes as user: security vehicles, administrative vehicles, ambulances and private vehicles. This legislation stipulates that only private vehicles should pay the toll. By-pass routes have been built specifically to allow the passage of road users on two wheels without toll payment, such a user is not taken into account in this work. A user is characterized by his type that is either public or private. Formally, a user U is defined by <Type, ID> where ID represents the identity of the user Type denotes the type associated to the user (private and public). In general, the identifier of a user actually represents the license plate number attached to each vehicle.

B. Barrier

The barriers are used to protect the electronic counter such that only one user at most can be inside this critical point of the tollgate at any given time. The barrier is characterized by

its state *(open or close),* formally a barrier is defined by I= <*open, close*> where open and close predicates are defined as follows:
Open: I → Boolean, Close: I → Boolean. So when i denotes a barrier, *open (i) = true* if the barrier *i* is open and *open (i) = false* otherwise. Similarly, *close (i) = true* if *i* is closed and *close (i) = false* otherwise. Every moment, *close (i) ≠ open (i).* In other words, a barrier is either open or closed.

C. Electronic counter

An Electronic counter consists of a card reader, a device for cash payment and possibly a ticket distributor. When a user arrives at the electronic counter, he inserts his card into the card reader, the card validity is checked, if the test is good, the card is returned to the user and payment is completed, or he introduces a coin in the equipment for this purpose, a check is done to see if the coin corresponds to $1, 1, if yes, the coins are registered and payment completed. The mode of payment is stored in the database; administrative vehicles and ambulances which are toll free have a special card issued on mission so that it is associated with the service vehicle and duration of mission so that it is used only for service purpose. Thanks to this card as they can cross through as subscribed user. Formally we can define an Electronic counter as follows: < Int, Exit, Wt, usr, fd, Nbv, pu> where

Int and Exit represent the inlet and the outlet respectivelty.

Wt is a test that determines if a user is waiting at the entrance of an electronic counter. This test shall be used to synchronize the opening of barriers. Thus, when gt denotes any electronic counter, $wt(g,t) = false$ when no user is waiting.

usr identifies the user if the electronic counter is occupied, from this fact, usr(gt,dt) is the user who was identified at the electronic counter gt on the date dt.

- fd is a function that determines at any time the income rt at the electronic counter gt at a given date dt with the constraint fd(gt,dt)=rt. The income is incremented by the tolls rate each time a private user goes through the electronic counter. Thus, when g is an electronic counter that has just been crossed by a private user over a spent time Δt for payment transactions then $fd(g,t+\Delta t) = fd(g,t) + tx$ where tx represents the toll.
- The function Nbv returns the number of cars that have crossed an electronic counter after a given date. The number of vehicles is increased by one at each transit. Thus, when g is an electronic counter that has just been traversed by a user who took a time Δt for payment transactions, the following constraint will be satisfied

$$Nbv(g,t+\Delta t) = Nbv(g,t) + 1$$

- Pu is a function that determines the number of private users who transited through a toll gate and actually paid the toll. Thus, when gt denote an electronic counter, if type(usr(gt,t))=public, then Pu(gt,Δt+t)= Pu(gt,t)+1

Lemma: Given an electronic counter g of a toll gate, at any time t, the income of g is proportional to the number of private users haven crossed that electronic counter. Thus, $Fd(g,t) = pu(g,t) \times tx$

The following properties provide constraints for opening and closing of barriers.
Property 1: The first barrier goes to state open when there is a waiting vehicle and the electronic counter is not busy.
Let g be an electronic counter,
$$open(Int(g)) \Leftrightarrow \left[wt(g) = true \wedge usr(g,now) = \perp \right]$$

Property 2: The first barrier is in the state close if no user is waiting, or if the electronic counter is busy. Thus if g is an electronic counter then the following constraint is satisfied
$$close(Int(g)) \Leftrightarrow \left(wt(g) = false \vee usr(g,now) \neq \perp \right)$$

Property 3: The second barrier closes up when the user at the electronic counter has completed the payment. Thus, let g be an electronic counter,
$$\left[fd(g,now) = fd(g,now-\Delta t) + tx \vee type(usr(g,now) = private \right] \Rightarrow open(exit(g))$$
Property 4: The second exit closes up when the user is out. Thus, if g is an electronic counter we have
$$(usr(g,now) = \perp) \Rightarrow close(Exit(g))$$

Axiom 1:
From modeling, there is always at most one user at a particular time at the electronic counter.
Axiom 2:
When the outlet is closed, the inlet opens automatically if there are users on hold.

D. Toll gate

A tollgate consists of two branches, one in each direction of vehicle traffic (It is assumed that each road has one lane in each direction). Formally a tollgate is a 5-tuple <G1, G2, fdT, NbvT,puT> Where:

G1, G2 are the electronic counter one on each direction.

fdT returns the total revenue of the tollgate which is the sum of revenues from its two electronic counters. So if p is a tollgate its recipe on the date t is given by fdT (p, t) = fd (G1 (p), t) + fd (G2 (p), t)

Similarly, the total number of cars having crossed the tollgate p on date t is NbvT(p,t)=Nbv(G1(p),t)+Nbv(G2(p),t)

puT is the function that determines the number of private vehicles haven crossed the toll gate. When p is a tollgate, the

number of private users haven crossed the toll at a date t is puT(p,t)=pu(G1(p),t)+pu(G2(p),t)

E. Toll zone

It is a set of toll gates put together for a common management. A toll zone is characterized by a set of toll gate, total revenue which corresponds to the sum of revenues from different toll gate of the zone, the number of vehicles and the number of private users who crossed the zone. Formally, Zone= (P, Rp, Vp, Pp) with P = {p| p□ Peage}: a set of toll gates; Rp a function that determines the revenue generated in the zone z at a given date t $Rp(z,t) = \sum_{p \in P(Z)} fdT(p,t)$;

Vp, a function that determines the number of vehicles that crossed a toll gate of the toll zone; Thus the number of vehicles which cross a zone z at a given date is given by $Vp(z,t) = \sum_{p \in P(z)} NbvT(p,t)$;

Pp is the function that determines the number of private vehicles that have crossed a toll zone:

$$Pp(z,t) = \sum_{p \in P(z)} PuT(p,t);$$

From a toll zone, we can zoom into a given tollgate in order to obtain its information.

F. Virtual Tollgate

The virtual toll gate presents an overview of all tollgates that have been created around the country. It is characterized by: the set of toll zones, global revenue, the number of vehicles passing through toll gates and the number of private vehicles crossing the tollgates. Formally, a virtual tollgate is defined by < Z, RT, VT, PT> where: Z = {z| z □ Zone} a set of zones;

RT a function that determines the revenue generated for the entire toll gates on a given date. Thus if w is the virtual toll gate, the revenue on a date t is

$$RT(w,t) = \sum_{z \in Z(w)} Rp(z,t),$$

VT the function that determines the total number of cars that pass through the different toll zones in Cameroon. We have $VT(w,t) = \sum_{z \in Z(w)} Vp(z,t)$,

PT the function that determines the number of private vehicles crossing the different toll zones. We have $PT(w,t) = \sum_{z \in Z(w)} Pp(z,t)$,

From the virtual toll gate, you can zoom into a zone to obtain information about this zone.

IV. PROTOTYPE IMPLEMENTATION

A. Specifications

To implement the proposed solution, roads at toll gates should be constructed first, so as to have at least two lanes in each direction: one lane for pedestrians and two-wheeled vehicles and at least one lane for motorists traveling in this direction. The toll gate should also be equipped with a system comprising the following elements: (1) two automatic barriers between which is the secure zone that contains the electronic counter reserved for the payment transaction, each barrier has a microcontroller to ensure that not more than a car is in the electronic counter at given time. (2) Sensors at each barrier to determine the presence of a vehicle at the entrance to a toll gate. When a vehicle is within range of the sensor field, its registration number is read and stored in the database. (3) A computerized card for collection. (4), a subscriber cards control system.

Passing through a tollgate is described by the following algorithm:

```
Cross algorithm ()
Begin
Detection by sensor;
While (lock! = 0)
    Wait ();
End while
Lock: = 1;
Open (barrier 1);
Enter the security zone;
Close (barrier 1);
Perform payment;
Open (barrier 2);
Leave the safety zone;
Detection by sensor
Lock: = 0;
Close (barrier 2);
End
```

The cross algorithm uses a shared variable lock which controls access to the critical section. If lock = 0 then the secure zone is free, otherwise it is busy and the car must wait. Initially, lock = 0. Payment operations shall be viewed from two angles: (1) for users without a subscriber cards, the user shall be allowed to introduce the sum of $ 1,1 in the electronic counter, verify the authenticity and value of money introduced and then generate a ticket if the tests were successful. (2) For users using a subscriber cards the system should allow the user to insert his card into the card control system, verify the validity of the card and return it to the user.

At each crossing, the information is stored in a local database and replicated to the central database that interconnects all the toll gates. If the connection to the central database is interrupted, the toll can work offline due to the local database. When the connection is restored, the data is switched to the central database. The tollgate then goes to the online mode.

The completed prototype must therefore be capable of simulating the passage of vehicles at tollgates and manage the various tollgates. It must create, disable, delete a subscription card, create, edit, view information about a given toll gate, to visualize the revenue of different toll gates.

B. Requirement of the future tool

In developing countries, financial, material and human resources are not always available for application's maintenance on the basis of changes related to its operation. Future users in most developing countries are not familiar with the IT tools. As such, the system that will be developed on the basis of this prototype shall be robust enough to overcome these shortcomings. This is a strong need in that applications that are developed in these countries do not always comply with quality standards because due sometimes to an insufficiency of funds or deficiency of staff. This constraint is particularly useful if the system will be deployed at various toll stations and staff may be assigned to another post, the system should not differ from one position to another. In addition, the software developed will allow interfacing with electronic components to be loaded at the box office and at the gates. On the other hand, over 70% of drivers have at most a primary school level. It is recommended to develop a user-friendly ergonomic system in order to prevent misuse at the tollgates due to the non mastery of the system. Finally, regulations are not stable in developing countries as it is often dependent on authorities. To enhance the adaptability of the system to future changes that may be made based on management choices, it is recommended that the future system be self-adaptive to prevent the mobilization of substantial funds in case of change.

C. Presentation of simulator

When a vehicle enters the field of the sensor, the microcontroller checks the state of the lock. If the electronic counter is available, the barrier opens and the user enters to perform the payment.

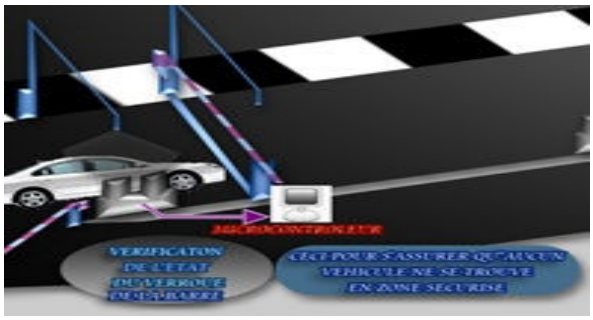

Figure.3 checking the availability of the secured zone

Entered the critical zone, the user performs the payment trough one of the payment modes (cash or card). The generation of the ticket causes the opening of the second barrier, which will be closed when the sensor no longer detects the presence of the vehicle.

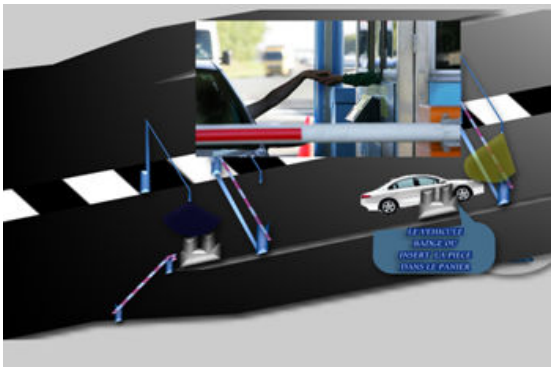

Figure.5 The user performs the payment transaction

When a vehicle is at the electronic counter, the others which come after must wait outside the barrier.

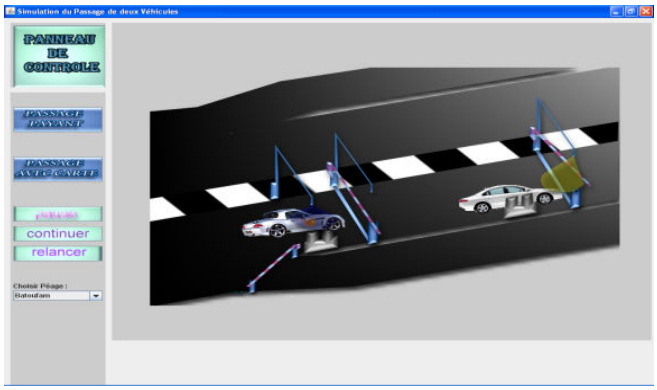

Figure.6 cars waiting

When the first car goes out, the closure of the second barrier triggers the release of the first barrier and the waiting vehicle can enter.

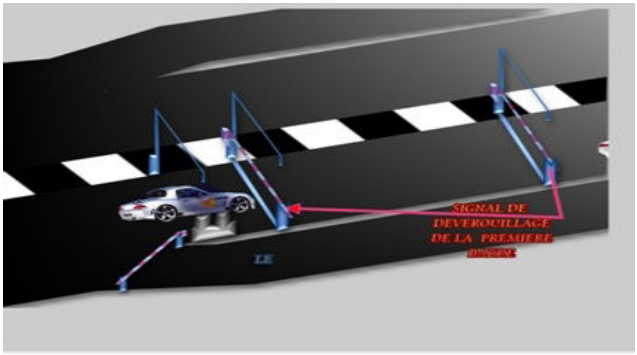

Figure.7 Release of the first barrier

V. CONCLUSION AND FUTURE WORK

After more than ten years of management of roads toll in Cameroon, the objectives of their establishment have not been achieved due to poor management related to manual processes. In this work, a model has been defined that would help in securing the revenue generated by tollgates. We have proposed a solution that permits in real time to have the toll

revenue on the national territory and the number of vehicles crossing each tollgate. In this model, a tollgate is represented by two secure zones, each containing an electronic counter where the various road users must perform the various payments before crossing. Access to secure zones is protected by automatic barriers equipped with sensors and microcontroller which ensures that at most one vehicle can be found at the electronic counter at any given time. In our approach we have identified two types of users: public users and private users. Private users are those who have to pay tolls while public users like security and health vehicle are those who normally do not pay tolls. In this regard, based on current legislation, any public vehicle which should cross a tollgate must have a specific card that will allow crossing the tollgate without paying the fees. When this card is used, all the information concerning the associated vehicle is contained in it such that it cannot be used by other roads' users. For this reason a matching is always done between information recorded in the card and the one instantly recorded during the tollgate crossing process. The transaction will be valid if and only if the match is successful. Following our model, we have developed a simulator to validate our approach. We believe this model can be used in developing countries to secure revenue from the payment of toll.

In future, we plan to refine the model with particular emphasis on the reliability of automatic recording of information contained in the license plates via a sensor on the one hand, and on the other hand to give crossing possibility to users without license plates in line with those required or not at all because in developing countries, the number of such users is significant.

VI. REFERENCES

[1] http://www.kwalai.com/toute-lactu-minute-by-minute/economie/4534 le péage routier bientôt automatisé, Septembre 2010,

[2] http://www.camerounactu.net/en/politic/government/261-gestion-suspicion-autour-de-la-baisse-des-fonds-du-peage-routier, Septembre 2010

[3] A. B. Cheikh, Y. Tourasse, A. Front, S. Coulondre, J. P. Giraudin. Vers une approche orientée processus métier pour les Systèmes d'Information de Transport.

[4] Ministère des Finances, Direction Générale des impôts (Programme de sécurisation des recettes routières PSRR), Direction Générale du budget (Comité interministériel de suivi des opérations du péage routier CISOPR), « recueil des textes relatifs au péage routier ».

[5] T.P.J. Tcheudjeu, « Stratégie d'optimisation des recettes du péage routier Camerounais », Mémoire de Master 2 de Statistique Appliquée.

[6] NUMBA_BACHUO AKAGBE, « Projet d'aménagement de la route : rapport d'évaluation, » Département de l'infrastructure OINF 2006),

[7] H. Tudor, « Modélisation des processus métiers : Etat de l'art et conseils pratiques», projet SPINOV, Juillet 2006

[8] Atsa Etoundi Roger, M.F. Ndjodo, P.E. Ndedi, G.A. Alo'o. "Improving the quality of service, Workflow based on the ant theory: a case study in Cameroon", The Electronic Journal on Information System in Developing Countries, Vol 41, n0 1,2010

[9] Atsa Etoundi Roger, Fouda Ndjodo Marcel and Atouba Christian Lopez, "A Goal Based Approach for QFD Refinement in Systematizing and Identifying Business Process Requirements", International Journal of Computer Science Issues, Vol 7, Issue 6, 2010

[10] Atsa Etoundi Roger, Fouda Ndjodo Marcel and Atouba Christian Lopez, "A Model based Business Process Requirement Rule Specification", International Journal of Computer Applications (0975 – 8887) Volume 11– No.9, December 2010

[11] Atsa Etoundi Roger, Fouda Ndjodo Marcel and Atouba Christian Lopez, "A Goal Oriented Approach for the Definition of a Business Process Requirement Model", International Journal of Computer Applications (0975 – 8887) Volume 9– No.7, November 2010

[12] Louis Berger International Inc. "Study to Improve Management and Financing of Roads", Final Report Prepared for the Ministry of Communications and Transport, Government of Zambia, Insaka; 1996

[13] Ivansson, Development of Good Governance in the Road Sector in Finland. Working Paper 21. World Bank, Sub-Saharan Africa Transport Policy Program, Africa Technical Department, Washington,D.C. 1995

[14] Gaviria, J. "Mobilizing Financial Resources for Rural Roads in Sub-Saharan Africa: Case Studies", World Bank, Sub-Saharan Africa Transport Policy Program, Washington, D.C. 1992

[15] Céline Kauffmann, « La participation du secteur privé aux infrastructures en Afrique », 11 December 2008

[16] Antonio Estache, « Africa's infrastructure: challenges and opportunities », Banque mondiale et ECARES, Université Libre de Bruxelles, 2006