I.J. Education and Management Engineering, **2017, 6, 14-23**
Published Online November 2017 in MECS (http://www.mecs-press.net)
DOI: 10.5815/ijeme.2017.06.02

Available online at http://www.mecs-press.net/ijeme

Mobile Device-based Cargo Gridlocks Management Framework for Urban Areas in Nigeria

John E. Efiong

Department of Information and Communications Technology, College of Natural and Applied Sciences, Wesley University Ondo, Nigeria

Received: 08 June 2017; Accepted: 11 September 2017; Published: 08 November 2017

Abstract

A number of recommendations for the adoption of ICTs in tackling traffic congestion problems in developing countries have been made in studies. Such studies have rather focused on assessing and evaluating the causes and effects of gridlocks than proffering solutions. The absence of implementable ICT models that can be effectively deployed to salvage the gridlocks, especially those generated by cargo transporters has added to the movement difficulty in these countries. This paper formulates a mobile device-based model supported by web technologies, called MobileCGM that can help avoid incidences of gridlocks emanating from Tin Can Island and Apapa sea ports in Lagos, Nigeria. This novel approach will allow timely pick-ups and deliveries of freights in the area by utilizing the deep penetration of GSM and mobile network services in Nigeria to solve the local problem. The model design and specification of the framework was achieved using the Unified Modelling Language (UML). The implementation of this model will render it needless for trucks and transporters to hang around the vicinity of where their cargos will be dropped off or picked up or cluster on the roads, as both cargo owners and transporters will know in advance when to pick up or deliver their cargo and get there just in time.

Index Terms: Cargo Traffic Congestion Avoidance, Gridlock, ICT, Mobile Device, Sea Ports, Lagos, Web Technology, Nigeria.

1. Introduction

Cargo movement via roads to and fro the seaports within and outside the major cities of developing countries have increasingly become issues of international concern. In Nigeria, cities like Lagos and Port Harcourt have

* Corresponding author.
E-mail address: john.efiong@wesleyuni.edu.ng

witnessed the worst cases of gridlocks in recent times. A gridlock is a state of a complete standstill in movement where continuous queues of vehicles disable a road network. It is an extreme form of traffic congestion or jam. These gridlocks have socio-economic and health costs on the nation. They shrink the Gross Domestic Product (GDP) of the nation, resulting from man-hour losses on the roads, damages to perishable goods, damages on vehicles, waste of petroleum products with which the vehicles run, high possibility of accidents [2] and overall operational costs on the commuters, drivers and the vehicles, degradation of urban environment, inducement of incidences of robbery and loss of revenue to the various stakeholders.

Gridlocks have also affected the health of commuters with unavoidable emissions of air pollutants and noise pollution, road rage and aggressions with verbal altercations which in most cases lead to fight and violence, and possibly loss of lives. Gridlocks induce stress disorders such as headache, backache, migraine, hypertension and respiratory disorders. Traffic stress syndromes also include high heart rates, sweaty palms, nausea, dizziness, stomach erupts, etc. Many factors account for these [4], [5]: there are problems of poor road network systems, road institutional management weakness, concentration of special facilities and infrastructure in certain locations, for instance, ports, tank farms, factories, etc., high concentration of offices and trading centres along major roads, flash floods on some of the roads, indiscipline by road users, high population concentration in Lagos and deteriorating state of some roads.

The Lagos Metropolitan Area, often called the Lagos City is a densely populated area of the State and witnesses tremendous industrial and commercial activities rated above 60% in the country. Lagos has a population of above 16 million, and rated as the seventh fastest growing city in the world, and the second largest city in Africa [9]. All these indices account for the ever increasing urbanization and traffic congestions experienced daily on the streets of Lagos. To contribute substantially to the GDP of the Transportation sector of the State Government, Lagos has two viable and optimally operational seaports – the Tin Can Island (TCI) Port and the Lagos Port Complex, Apapa [8]. According to the Corporate and Strategic Planning Division of the NPA, as at the third quarter of 2016, the provisional figures of cargo traffic (excluding crude oil) of Apapa and TCI ports were quoted as 5,360,685 metric tons and 4,166,552 metric tons respectively for throughputs classified according to trade. The container traffic (in TEUs) showed 136,543 and 179,443 while the vehicle traffic (in units) showed 3 and 25,430 for Apapa and TCI respectively [8]. Each of these ports generates traffic higher than the four other ports in Nigeria including Rivers, Onne, Delta and Calabar combined. With the road being the major channel of transportation in Nigeria, it is clearly seen what volume of traffic would be generated, coupled with other industrial, corporate and private road users. It is only important therefore, that an intelliegent workaround be made to circumvent traffic gridlocks on our roads.

Mobile communication technology has been around in Nigeria for almost two decades now, having massive potential for more penetration. Over 65% of Nigerians now have access to basic-featured cell phones, while the sophisticated ones are gaining popularity [15]. The mobile services operations in the country have been made possible by four operators, including MTN, Globacom, Airtel and Etisalat with their 2G and 3G services, while 4G services are being offered by operators like Smile, Spectranet and Swift [6]. Nigeria is measured as having the largest mobile market in Africa, with about 150 million subscribers and a penetration rate of 107%. A projection made by [13] of the number of smartphone users in Nigeria from 2014 to 2019 (in millions) reveals that about 18 million Nigerians would have possession of smartphones in 2017, 20.5million in 2018 and 23.3million in 2019. With this rapid penetration and proliferation of mobile devices in Nigeria, it's time they become useful in solving the local problems of the country. Mobile services have the capacity to help drive developmental policies and sustainable growth processes as it is today in Nigeria if fully harnessed. The craze for apps and websites in recent times in the nation can be turned into a problem-solving gift, such as in gridlocks avoidance and/or resolution.

As stakeholders in the Nigerian economy, Cargo/freight handlers can utilize this technology in solving their immediate problem of products pickups and deliveries as scheduled without major hitches on the roads. These handlers include the Cargo Generating Organizations (CGOs), Cargo Receiving Organizations (CROs), Cargo Owners (COs), Haulagers/Transporters, Cargo Agents (CAs), etc. The CGOs are locations within the metropolis where trucks/trailers/tankers go to pick up cargos such as the ports, petroleum products tank farms,

industrial/manufacturing concerns, etc. They include those organizations in places under the superintendence of the Nigeria Ports Authority for pickups. These include the ports concessionaires, shipping companies, all occupiers of NPA premises with appreciable trucks traffic, etc. The CROs are places under the oversight of the NPA where cargos are delivered to within the metropolis and these include the ports, industrial/manufacturing concerns, etc. The COs are the owners of the consignments or cargos to be hauled or transported. They may also be represented by their agents (CAs) and the haulagers are the transporters of the cargos to be ferried across the metropolis. They may be called the trucks/trailers or tankers drivers. These stakeholders have access to mobile phones that can be used to address the hitches they face daily on the roads.

2. Related Works

In identifying traffic congestion as necessary evil for modern society, [5] evaluated the effects of road gridlock on freight movement in Lagos metropolis. By doing multiple regression analysis on data obtained through questionnaire, the study revealed that freights carriage delay on transit would result in longer travel times, underutilization of vehicles, reduced fuel efficiency, higher operation cost of fleet, reduction in market share and less reliable pick-ups and deliveries for transporters. As a traffic reduction strategy, the study by [5], just like [1] proposed an intelligent transportation system which would include the adoption of an integrated modern intelligence for traffic reporting through radio or mobile devices, with an inclusion of navigation systems, surveillance systems, etc. for direction and guidance information. Since these studies were explorative, they did not present any model rather than the suggested ways-out.

[4] examined the traffic management problems that would result from traffic congestion along Alaba International Market Road, Ojo, Lagos State. Using survey research technique through the administration of questionnaires, the study sampled the opinions of commuters, commercial vehicle operators and private car owners on the causative factors of traffic jam on the study area, which the study identified as encroachment of the market into the road, overloading of vehicles, the narrow nature of the road, reckless driving, incessant parking, unregulated loading and offloading of both passengers and goods along the road, etc. With these, the study recommended, among other things, the dualization of the road, availability of adequate bus stops, parks, etc. Notably, the study suggested a deployment of effective traffic management mechanism, which in the view of this paper could mean application of modern technological gadgets for traffic monitoring and control. Since the focus of the study was on an assessment rather than proffering an IT solution, it did not address any key IT technique that can be deployed. Earlier, [12] had explored similar options, which he described as cars-restraint measures, and prompted the enforcement of fines on traffic offenders which he stressed should be high enough to deter others. Reference [12]'s work went further to present the benefits of an electronic-based working framework for traffic control without uniquely identifying what technology such a framework could rest upon.

A similar assessment study was undertaken by [11] which focused on traffic congestion problems in central business district (CBD) of Ikeja, Lagos Metropolis. The study examined the challenges of traffic congestion and management problems within the study area by obtaining data through questionnaire administration and quota sampling method and made recommendations. In the same vein, [10] carried out an evaluation of traffic congestion situation in Lagos. He underlined that Road traffic congestion has remained a global occurrence that has in diverse ways retarded the economic growth of developing cities of the world with massive population, like Lagos - the commercial hub of Nigeria. The study pointed out the efforts of the government of the State toward ameliorating the traffic situation, by introducing the novel Bus Rapid Transit (BRT) with its dedicated-lane. Other developments in this regard has been rapid expansion of roads network, improvement on drainage systems to allow free flow of traffic during rainy periods, introduction of traffic lights, constitution and equipping of traffic management agencies, such as the Lagos State Traffic Management Authority (LASTMA), Metropolitan Area Transport Authority (LAMATA) and consequent deployment of trained traffic personnel, etc. [3]. The study further explored the causative factors of gridlocks like the work of [14] and advocated for integration ICTs such as Automated Traffic Monitoring and Real Time Road Users' Traffic Situation Reports Systems to effectively manage the major roads. The technologies behind these systems and their workability in

Lagos State were not described in the study, except their being recommended. More so, the study focused on the overall management of the transportation sector of the State and other intercity movements along major Nigerian roads, namely, Lagos-Ibadan Expressway, Abuja-Lokoja Expressway, etc. with no emphasis on gridlock incidences caused by heavy duty transporters, and freights carriers. As a way of solving traffic problems in urban areas by utilizing digital technologies, [16] proposed a novel vehicle classification model for urban traffic surveillance using the deep neural network model. The system could be used for the tracking vehicles and classifying vehicular objects. The aim of the study was on modelling vehicular traffic without necessarily providing avoidance mechanisms in congested scenarios. Similar studies were carried out by [17], [18], [19], [20] and [21].

A recent work so far reviewed on traffic congestion with direct connection with mobile device deployment was carried out by [7]. The study proposed a framework that would utilize GSM, along with Global Positioning System (GPS) for traffic congestion detection. The aim of the integrated technique was to detect the status of the roads and furnish road users with such information to enable them ply alternative routes to their destinations. [22] proposed similar approach by implementing a mobile phone based road information management system which integrated three modules for data collection, storage and information dissemination. According to the study, the modules worked together to enable real-time traffic control using mobile phones facilities. [25] however, believed bad road conditions, including potholes, bumbs, etc. were possible causes of traffic jams, accidents and vehicle damages in urban areas, and therefore proposed a road monitoring system that could report these conditions to appropriate agencies of government for immediate possible response. The participatory sensory system proposed relied upon raspberry pi to detect road situations based on measurements from Inertial Management Unit (IMU) and GPS. The system also ran on android-based platform supported by message queuing telemetry transport protocol.

This research extends their studies by formulating congestion avoidance framework that addresses the gridlock problems headlong based on GSM use and web technology. Previous studies that focused on the adoption of mobile phones technology for improving the livelihood of humanity were carried out by [23] and [24] as cited by [22].

3. Proposed Experimental Design

The proposed model, to be called Mobile Device-based Cargo Gridlocks Management Framework (MobileCGM) is a mobile platform-based model, supported by robust database web technology. The Unified Modeling Language (UML) was used for the design and specification of the model. There are eight major players in the model as seen in Fig. 1, namely: the Telco, CGO/CRO, CO/CA, Haulager, Waiting Bay, web portal, Web Server and Traffic agency, described as follows:

i. Telco => Telecommunication (mobile network) service provider that a stakeholder subscribes to.
ii. CGO/CRO => Cargo Generating/Receiving Organization
iii. CO/CA => Cargo Owner/Cargo Owner's Agent
iv. Haulager => Transporter of the Cargo, i.e Truck/Truck Driver
v. Waiting Bay => Temporary waiting location for Trucks pending pickup/delivery time as scheduled
vi. Web Portal => Online user-friendly interface for registration, booking, etc.
vii. Web Server => Cloud-based storage
viii. Traffic Agency => Authorized traffic Agency of Government

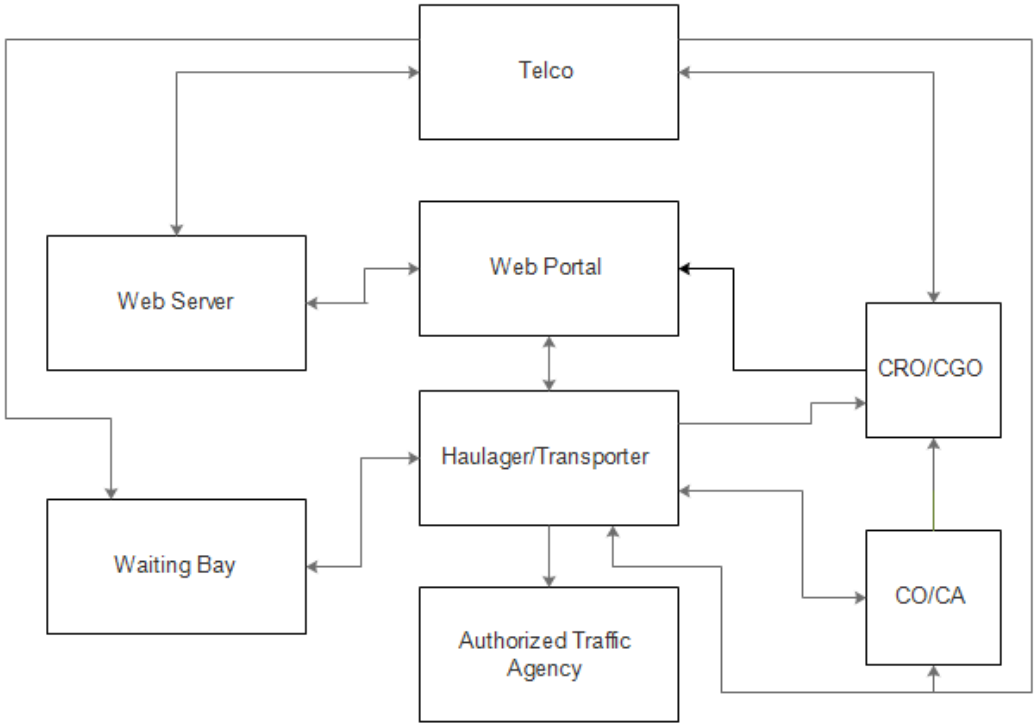

Fig.1. MobileCGM Block Diagram

Step 1: The CRO/CGO consummates relationship with the CO who owns Cargo to be picked up from the CGO or dropped with the CRO. This relationship may be offline or via mobile devices (SMS, calls, chats, pings, skype, etc) and the expected fee paid.

Step 2: The CRO/CGO signs up on the web portal with required details (Company's name, location, phone no, email, username, password, etc). A very important aspect of the signup process is that the CRO/CGO must specify the maximum number of Cargos (shipments) to be picked-up/delivered daily. This information is vital for scheduling and preparing movement rosters. These records are stored in the web server. On successful registration on the portal, server issues a unique personal identifier – Booking Number (BN) to the CRO/CGO via the phone number supplied.

Step 3: The CRO/CGO logs into the portal with the username and password to upload details of the CO/CA and Haulager (mobile phone numbers are a key requirement in this process) based on their agreement in *step 1*. The flowchart of the first three steps is shown in Fig. 2. As illustrated in the flowchart, the CRO/CGO must register successfully with the system via the web portal, after which they can proceed to signing up the CO/CA following the consummation of relationship and payment of agreed royalty.

Step 4: The server assigns a unique Cargo Identification Number (CIN) to CO/CA/Haulager's phone numbers registered by the CRO/CGO through the Telco.

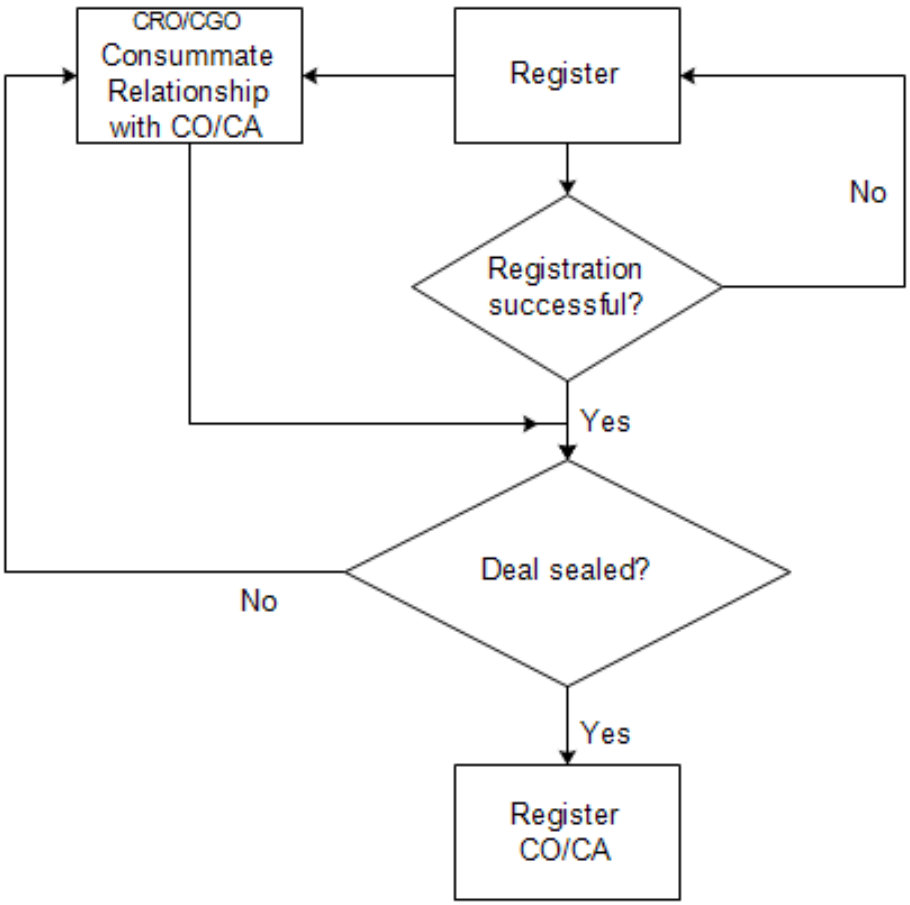

Fig.2. Flowchart of CRO/CGO Subsystem

Step 5: The CO/CA/Haulager sends customized SMS with the CIN to a dedicated Short Code released by Telco, requesting pick-up/delivery. See Fig. 3. The Telco forwards this SMS to the web server to match the availability of freights at the CRO/CGO based on schedules. On confirmation, a link is generated from the server for a printable Cargo Movement Permit (CMP) and sent to CO/CA/Haulager via the Short code. Where the CRO/CGO has reached the maximum schedule for the day, the CO/CA/Haulager is informed via the same Short code.

Step 6: Where there are delays, disruptions or cancellation of bookings at the CRO/CGO, messages are dispatched from the server via the Telco/Short code to the CO/CA/Haulager and Waiting Bay as seen in Figs. 4 and 5. The Haulager is directed to the Waiting Bay while the issues are sorted out. This way, no Haulager is found on the roads or clustering around the CRO/CGO until it is their time to pick-up or drop cargo.

Step 7: An Agency of Government is expected to be empowered with requisite authority to check every Haulager on the roads with the CMP. It is the CMP that authenticates if the Haulager is on schedule or otherwise. Necessary legal actions are expected to be followed on defaulters.

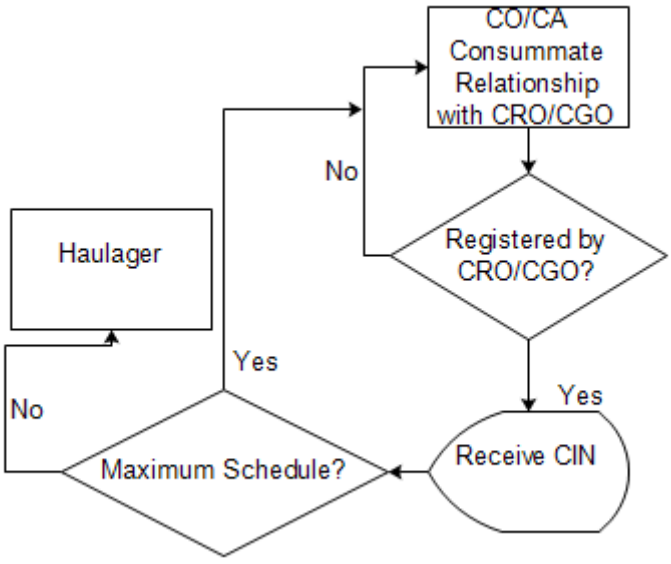

Fig.3. Flowchart of CO/CA Subsystem

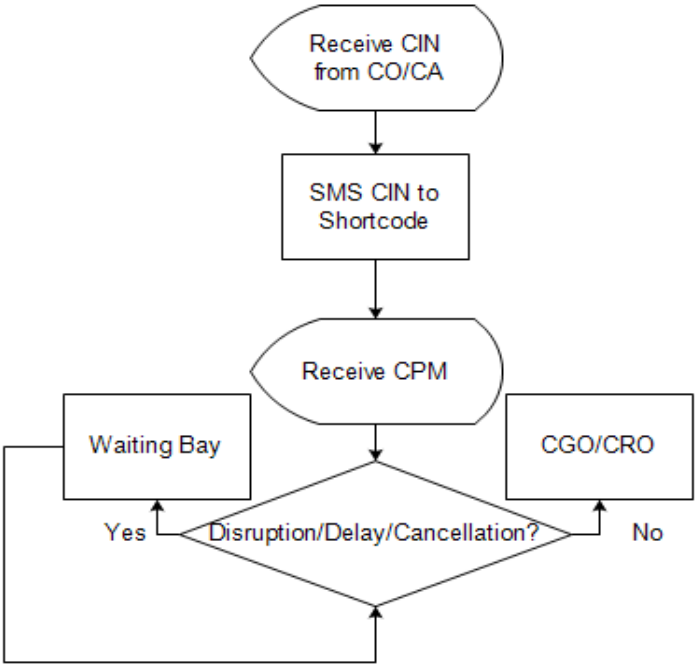

Fig.4. Flowchart of Haulager Subsystem

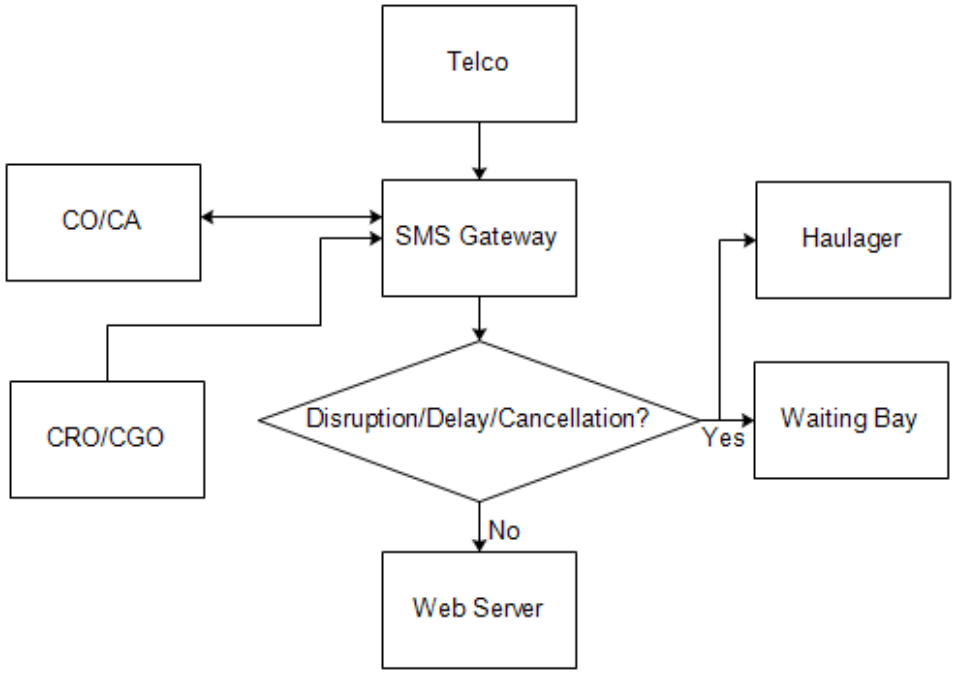

Fig.5. Flowchart of Telco/Mobile Subsystem

4. Discussion

The MobileCGM is a traffic congestion avoidance system. The result of such a framework will be a multi-sectoral fleet management system designed to address the challenges of traffic gridlocks occasioned by the activities generated by operators (seaport terminal operators, petroleum products depot owners, port land licensees, trailer/truck drivers carrying freights, etc) working in and around the ports. The MobileCGM would seamlessly interface with cargo loading rosters/schedules of identified cargo generating/receiving organizations (CGOs/CROs) taking into consideration their dynamics and daily terminal capacities by allowing a convergence of rosters onto a single platform, thereby eliminating build up of vehicle clusters in and around the ports. The system is expected to have a user-friendly, scalable and interactive web portal that provides a platform for monitoring and tracking of cargo loading and/or delivery activities. The principles of building human-computer interactive systems are to be employed in developing the system, such that non-technically savvy stakeholders can effectively interact and use the system. Such ergonomics will eliminate complexities or rather hide them for optimal operation by call categories of users.

With the MobileCGM in place, it will become needless for trucks to hang around the vicinity of where their cargo will be dropped off or picked up as both cargos owner and transporters will know in advance when to pick up or deliver their cargo and get there just in time. The goal is to avoid incidences of gridlocks. By allowing only Haulagers on schedules, authorized by the Cargo Movement Permit (CPM) and identified by an Agency of Government, the roads will be freer. This way, the occurrences of heavy traffic congestions by moving cargos to and from ports and other NPA authorized locations will be avoided. This avoidance mechanism will solve the local traffic problem associated with freights movements in the area under the study.

5. Conclusion

The MobileCGM executes through the four subsystems discussed in seven steps, including the Haulager Subsystem, CO/CA Subsystem, CRO/CGO Subsystem and the Telco/Mobile Subsystem. The mobile platform uses two major objects – the phone numbers of the stakeholders and a dedicated short code for interaction with the system through dialling a USSD or sending SMS to the short code. These services are provided by mobile network providers – MTN, Globacom, Airtel and Etisalat. A simple cell phone with dialling and messaging facilities can be used to interact with the system and achieve same results as smart phones, except in downloading a printable cargo pick-up/delivery permit. This arrangement would avoid traffic congestions emanating from ports activities and allow free-flow of traffic in Lagos.

References

[1] Aderamo, A. J. "Urban Transportation Problems and Challenges in Nigeria: A Planner's View". *Prime Research on Education* (PRE), 2012, 2(3): 198-203, Available at www.primejournal.org/PRE.

[2] Agbonkhese, O; Yisa, G. L; Agbonkhese, E.G; Akanbi, D.O.; Aka, E.O and Mondigha, E. B. **"**Road Traffic Accidents in Nigeria: Causes and Preventive Measures"**.** *Civil and Environmental Research*, 2013, 3(13):90-100.

[3] Aworemi, J. R., Abdul-Azeez, A. J. Oyedokun and J. O. Adewoye. "A Study of the Causes, Effects and Ameliorative Measures of Road Traffic Congestion in Lagos Metropolis". *European Journal of Social Sciences,* 2009, 11(1).

[4] Eniola, O. J., Ikpechukwu, N., Akinsulire, E. S. and Enosko, O. "Traffic Management Problems in Lagos: A Focus on Alaba International Market Road, Ojo, Lagos State Nigeria". *Journal of Economics and Sustainable Development*, 4 2013, (4):144-154.

[5] Fadare, S. O. and Ayantoyinbo, B. B. "A Study of the Effects of Road Traffic Congestion on Freight Movement in Lagos Metropolis", *European Journal of Social Sciences,* 2010, 16(3):429-437.

[6] GSMA Digital Inclusion. Digital Inclusion and the Role of Mobile in Nigeria. Retrieved from www.gsma.com/digitalinclusion, 2015. Accessed 24/04/2017.

[7] Idachaba, F. E. and Ibhaze, A. E. "GSM/GPS Assisted Road and Traffic Congestion Detection System". *International Journal of Applied Engineering Research*, 2016, 11(24): 11610-11613. Research India Publications. Retrieved from http://www.ripublication.com. Accessed 24/04/2017

[8] Nigerian Ports Authority (2017). *Nigerian Ports Authority Statistics*. Retrieved from http://www.nigerianports.org/defaultLagosPort.aspx?Pid=274**.** Accessed 24/04/2017.

[9] Nwagwu, I. and Oni, T. (2015). "Lagos and Its Potentials for Economic Growth. Heinrich-Böll-Stiftung". Retrieved from https://ng.boell.org/2015/07/02/lagos-and-its-potentials-economic-growth. Accessed 24/04/2017.

[10] Olagunju, K. "Evaluating Traffic Congestion in Developing Countries – A Case Study of Nigeria". A Paper Presented at the 2015 Chartered Institute of Logistics and Transport (CILT), Africa Forum, Mount Meru Hotel Arusha, Tanzania, 4th March, 2015.

[11] Olayiwola, K. O., A. M. Olaseni and O. Fashina. "Traffic Congestion Problems in Central Business District (CBD), Ikeja, Lagos Metropolis, Nigeria". *Research on Humanities and Social Sciences*, 4(1):23-32.

[12] Oni, O. A. G. "Tackling Road Traffic Congestion in a Developing Country – A Contemporary Approach". *Journal of Applied Sciences Research,* 2010, 6(5): 529-542.

[13] Statista. (2014). *Number of smartphone users in Nigeria from 2014 to 2019* (in millions). Retrieved from https://www.statista.com/statistics/467187/forecast-of-smartphone-users-in-nigeria/. Accessed 24/04/2017.

[14] Ukpata, J. O. and A. A. Etika. "Traffic Congestion in Major Cities of Nigeria". *International Journal* of Engineering and Technology, (IJET), 2012, 2 (8): 1433-1438.
[15] Efiong, J. E. and F. O. Aranuwa (2017). "Mobile Devices' Features and Usability: The Nigerian Utilization Experience". International Journal of Computer Trends and Technology (IJCTT), 2017, 48(4), 200-207.
[16] Goyal K. and D. Kaur, "A Novel Vehicle Classification Model for Urban Traffic Surveillance Using the Deep Neural Network Model", *International Journal of Education and Management Engineering(IJEME)*, 2016, 6(1):18-31,.DOI: 10.5815/ijeme.2016.01.03
[17] Chen, X., Shiming, X., Liu,C. L., and Pan, C.H. "Vehicle Detection in Satellite Images by Hybrid Deep Convolutional Neural Networks". *Geoscience and Remote Sensing Letters*, IEEE 11, 2014, 11(10): 1797-1801.
[18] Sivaraman, S., and M. M. Trivedi. "Looking at Vehicles on the Road: A Survey of Vision-based Vehicle Detection, Tracking, and Behaviour Analysis". *Intelligent Transportation Systems, IEEE Transactions*, 2013, 14(4): 1773-1795.
[19] Mithun, N. C., Rashid, N.U. and Rahman, S.M.M. "Detection and classification of vehicles from video using multiple time-spatial images", *IEEE Transactions on Intelligent Transportation Systems*, 2012, 13(1):1215-1225.
[20] Mei, X. and Ling, H. "Robust Visual Tracking and Vehicle Classification via Sparse Representation", IEEE Transactions on Pattern Analysis and Machine Intelligence, 2011, 33(1), 2259-2272.
[21] S. Peng, C.A. Harlow, "A System for Vehicle Classification from Range Imagery", *Proceedings of the* IEEE 28th Southeastern Symposium on System Theory, 1996, 327-331.
[22] Runyoro, A. K. and Ko, J. "Mobile Phone Based RIMS for Traffic Control a Case Study of Tanzania", International Journal of Information Technology and Computer Science (IJITCS), 2015, 7(5): 55-60. DOI: 10.5815/ijitcs.2015.05.08
[23] Duncombe, R., Researching Impact of Mobile Phones for Development: Concepts, Methods and Lessons for Practice. *Information Technology for Development*, 2011, 17(4): 268-288.
[24] Duncombe, R. Understanding Mobile Phone Impact on Livelihoods in Developing Countries: A new Research Framework. *Manchester Centre for Development Informatics*, Working Paper 48, 2012; Available at the website: http://www.sed.manchester.ac.uk/idpm/research/publications/wp/di/di_wp48.htm. (Accessed on 12th September, 2017).
[25] Ahmad, M., Raza, W., Omer, Z. and Asif, M. "A Participatory System to Sense the Road Conditions", *International Journal of Engineering and Manufacturing(IJEM*), Vol.7, No.3, pp.31-40, 2017.DOI: 10.5815/ijem.2017.03.04.

Authors' Profiles

John E. Efiong is a member of faculty of the Department of Information and Communications Technology, College of Natural and Applied Sciences, Wesley University Ondo, Nigeria. He is the pioneering coordinator of the Centre for Innovation, Research and Development (CIRD) at Wesley. His research area covers Mobile/Pervasive Computing and Software Engineering. He has previously worked as Network Engineering Technician, Web Programmer and Software Solutions Developer, with focus on mobility and human-computer interaction.

How to cite this paper: John E. Efiong,"Mobile Device-based Cargo Gridlocks Management Framework for Urban Areas in Nigeria", International Journal of Education and Management Engineering(IJEME), Vol.7, No.6, pp.14-23, 2017.DOI: 10.5815/ijeme.2017.06.02